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1

FINAL REPORT OF THE NATIONAL TESTING SURVEY

ANNEX 1

UFFI REFERENCE CENTRE
CENTRE DE DOCUMENTATION
DE LA MIUF

TECHNICAL SPECIFICATIONS FOR FEDERAL GOVERNMENT 2,300 HOME TEST PROGRAMME, 1981.

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CO[illegible]
LI[illegible]
JAN 31 1984
BIBLIOTHÈQUE
MINISTÈRE DE LA CONSOMMATION
ET DES CORPORATIONS

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CENTRE DE DOCUMENTATION
DE LA MIUF

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Procedure for the Enumeration of the Fungal Air Spora 16 October 1981

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Amendments to Quality Assurance/Quality Control Specifications:

Outline of Responsibilities - Quality Assurance/Quality Control September 1981

Letter from Concord Scientific Corporation containing technical revisions based on Outline of Responsibilities of the QA/QC Contractor September 18, 1981

PROCEDURES MANUAL FOR THE
SAMPLING OF HOMES INSULATED
WITH UREA FORMALDEHYDE FOAM

Department

of

CONSUMER AND CORPORATE AFFAIRS

September 1981

TESTS SUMMARY

A MANDATORY

1 REVISED NIOSH FOR FORMALDEHYDE

2 air samples collected indoor
1 air sample collected outdoor
+ 10% Replicate and blanks

1 blank per house

2 FORMALDEHYDE (DRAGER TUBE) TEST

a - preceding each indoor NIOSH: 2 measurements/house

b - in wall cavities: 10 measurements/house

3 WATER VAPOUR DETECTOR TUBE TEST

(Drager, Gastec, or Matheson)

in wall cavities: 10 measurements/house
(same locations as 2(b)

4 WOOD MOISTURE CONTENT

In wood framings in wall cavities: 10 measurements/house
(same locations as 2(b)

5 FUNGAL TESTS

10 swabs - to be returned in one sterile container

6 petri dishes samples

6 TEMPERATURE AND RELATIVE HUMIDITY MEASUREMENTS
(at the beginning and end of each NIOSH sample)

4 indoor measurements
2 outdoor measurements

7 WINDSPEED AND DIRECTION MEASUREMENT

on measurement upwind of the house

8 PASSIVE DOSIMETER (When supplied)

DuPont	2 per house (total 4600) + 5% replicates and 2% blanks
Detectronics	1 per house (total 500) + 5% replicates
Oak Ridge	1 per house (total 500) + 5% replicates and 2% blanks

B **IF REQUIRED**

1 IMPINGER COLLECTED SAMPLES FOR INTEFERING GASES (ALDEHYDE ONLY)

as described in Test Protocols, Section 2.5.1.1

Maximum of 2 samples/house
(The samples are collected from air in wall cavities in a manner similar to NIOSH test)

2 AMMONIA DETECTOR TUBE TEST

(Drager, Gastec or Matheson)

1 per Drager Formaldehyde Tube when interfering gas present in lower hole.

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TESTS SUMMARY

I INTRODUCTION

This document has been prepared as a procedures manual for the testing of homes insulated with urea formaldehyde foam (UFFI).

Testing in these homes with UFFI will require:

- house preparation

- a series of temperature and moisture content of air measurements taken inside and outside each home using a psychrometer

- a measurement of windspeed and wind direction outside each home taken during the test period using a portable anemometer

- a series of fungal spore samples taken on swabs in specified locations throughout each house.

- a series of fungal spore samples taken inside each house by exposing petri dishes containing malt agar to room air.

- a series of wall cavity and joist space measurements of formaldehyde gas using a hand held pump and appropriate Dräger formaldehyde gas detector tubes in at least ten locations in each home (except in reference homes where no wall cavity measurements will be made). In order to allow access to wall cavities to perform these measurements, an electric drill and 11/32" and 1/4" size drill bits will be required. An appropriate water vapour detector tube will also be required in each drilled opening.

- a series of further tests will be necessary where a yellowish-orange discoloration appears on Dräger formaldehyde tubes. In each case of discoloration, a test for the presence of ammonia gas in the wall cavity will be required using a hand held pump and appropriate range ammonia detector tube. In addition, not more than two samples of wall cavity air collected in an acidic impinger solution of 2,4-dinitrophenylhydrazine will be required in each home where discoloration of Dräger formaldehyde tubes is detected. Analysis of these impinger collected samples will be arranged by the National Research Council.

- at least two modified NIOSH P&CAM #125 impinger collected samples taken inside each home and one taken upwind, outside each home, to be colorimetrically analyzed for the presence of formaldehyde gas.

- at least ten wood moisture content measurements of studs using a resistivity type moisture meter in each home (except in reference homes where no wood moisture content measurements will be taken).

Each field team performing these tests will be required to contact home residents to confirm a test date, and to instruct the resident on the necessary preparation of the house prior to testing.
The team will also be responsible for the recording of meteorological data for the test date and test time, collected from an Environment Canada or Transport Canada weather station located in the vicinity of the house being tested.

A questionnaire found in Appendix C, will be administered to home residents by the technician teams on site while samples are running.
A field team will set up two passive DuPont type C-60 badges in each of the homes to be tested. The team will also instruct home residents on sample duration, handling, record keeping, and shipping of these passive devices to be subsequently

performed by the residents. These devices may be analyzed by an outside laboratory.

Record keeping on provided forms, (see Appendix D), and the transmittal of these forms to the designated locations will be required following each home tests.

Oak Ridge National Lab and Detectronics passive dosimeters to be used in a small proportion of test homes may be introduced at a later date. These devices will require approximately the same time and technician team input as the DuPont badges require.

Testing in reference homes:

One out of every six homes will be a home which does not contain UFFI, referred to as a "reference home". Testing in these homes will require:

- house preparation
- NIOSH impinger samples - two inside and one outside the house
- fungal spore swabs
- fungal spore samples collected on treated petri dishes
- indoor and outdoor temperature and air moisture content measurements
- outdoor windspeed and wind direction measurements.

Meteorological information will be collected in relation to each of these homes. the questionnaire will be administered, and in each of the reference homes passive DuPont monitors will be set up with further instruction being given to residents on how to procede with DuPont tests in the week following the technician team visits. In all caces, test and related requirements will be performed in exactly the same manner in reference homes and in UFFI insulated homes.

Wall cavity, joist space and wood moisture content of stud tests will not be performed in reference homes.

The equipment and other requirements for the performance of each test, are presented in summary form in Table 1. The main body of the manual details sample preparation, on-site procedures and testing follow-up requirements.

TABLE 1

EQUIPMENT LIST AND SPECIFICATIONS

PROCEDURE MANUAL SECTION	PROCEDURE	EQUIPMENT SPECIFICATIONS	SUPPLIED BY
2.3.2	Windspeed outside house. Wind direction outside house.	Portable Anemometer accurate to ± 10% with compass (such as EfstonScience cat. no. 42,547 about $59.50)	Contractor
2.3.2	Indoor temperature Indoor humidity	Psychrometer (portable) (such as EfstonScience cat. no. 71,477 about $59.50)	Contractor
2.4.1	Fungal Spore swabs	Swabs and sterile container	Contractor
2.4.2	Petri Dish Fungal Spore Collection	Sterile Petri Dish containing nutrient	Contractor
2.5.1	Wall cavity detector tube measurements	Dräger Multi Gas Detector hand held pump with stroke counter	Contractor
		OR Gastec Gas Detector Pump	"
		OR Kitagawa Sample Kit	"
		Drager Formaldehyde Detector Tubes	"
		Low Range: 0.5/a High Range: 0.002	"
		Dräger Ammonia Tubes	"
		Low Range: 5/a High Range: 25/a	"
		Matheson Ammonia Tubes	"
		Low Range: 8014-1055a High Range: 8014-1055a	"

TABLE 1

EQUIPMENT LIST AND SPECIFICATIONS

PROCEDURE MANUAL SECTION	PROCEDURE	EQUIPMENT SPECIFICATIONS	SUPPLIED BY
2.5.4	Wood moisture content of frame members	Resistivity type moisture meter (such as Delmhorst Instrument Co., Model G-22, and Probe Model #26-E) extra long probe	Contractor
		Stud (nail) Finder	Contractor
		Gastec Ammonia Tubes	Contractor
		Low Range: 1G3L High Range: 1G3M	
		Drager (0.1), Gastec (1G6) or Matheson (8014-177) Water vapour Detector Tubes	Contractor
		-Power drill and 11/32" bit and 1/4 " bit	Contractor
		- tape	"
		-polyfilla or other filler	"
		-tape measure	"
		-6' ladder	"
2.6	Air samples		
		glass or polypropylene straight walled 25 ml. midget impinger and poly-propylene 25 ml transfer bottles	
		-parafilm (obtained from any laboratory supply house)	"
		-20ml. and 10 ml pipettes and bulbs	
		-vacuum pumps, mains powered	"

TABLE 1

EQUIPMENT LIST AND SPECIFICATIONS

PROCEDURE MANUAL SECTION	PROCEDURE	EQUIPMENT SPECIFICATIONS	SUPPLIED BY
2.7	Passive dosimeter DuPont	-1 litre of air per minute flow limiting orifice	Contractor
		-AC pumps should be capable of maintaining a vacuum of at least one half an atmosphere at a flow rate of 1 litre per minute across limiting orifice	
		vacuum pumps, consistant flow battery powered, capable of pulling one litre of air per minute for at least 8 hours per day	Contractor
		-1½ metre heavy bottomed ring stand and clamps	Contractor
		-tygon tubing	"
		-clean glass wool	"
		-camera tripod with adjustable legs	"
		-labels	"
		-funnels -clamps	"
		Wire or string for suspending badges	Contractor
		DuPont formaldehyde Type II C-60 bdges	National Research Council
	Oak Ridge National Detectronics	dosimeters	"

Equipment required in the performance of sample analysis is specified in Appendix B.

2.0 REQUIRED TEST PROCEDURES

2.1 House Preparation

The following procedures are designed to eliminate large interferences that might affect the meaningfulness of the results. The intention is to create a bias towards high gas concentrations and the absence of inteferences so that a "one stop" house test will be adequately informative.

A complication to measuring formaldehyde gas concentrations in houses is caused by the effects of temperature and humidity on indoor gas concentrations. Measurements taken during hot, humid summer months are generally higher than those taken during cold winter months. Consequently, it is very important to record the environmental data at the time of the testing.

Procedure for house preparation (UFFI and reference homes)

Eighteen Hour House Close-Up

The homeowner will be instructed to operate the house as follows for 18 hours before the test:

- ensure that the minimum house air temperature is 20°C. This means leaving the thermostat up overnight (no night set-back) during cold weather and leaving air conditioning devices off or on recirculation mode only, during warmer months; (NOTE: if the occupants' comfort is adversely affected by these measures, evacuation of the house should be suggested for the test period.)

- provided that this minimum temperature is maintained the heating system should be run in a normal operating mode.
- close all windows, fireplace vents, or attached garage doors, etc.

During this 18 hour period the homeowner SHOULD NOT:

- operate ventilation devices such as kitchen and bathroom vent fans (ensure that their flappers are closed), air conditioning devices.
- generate any smoke by frying, broiling, smoking, etc. difficult / [illegible] smokers
- operate automobiles in attached garages or carports where fumes may collect
- open doors between indoors and outdoors (if necessary, enter/exit quickly).
- open garage doors in attached garages
- use paint, varnish, paint thinners, lacquers, air fresheners, or any aerosols.

2.2 Procedure On-Site Prior to Making Measurements

Prior to beginning any indoor tests, the technician should:

- enter the house quickly
- set the thermostat to 14°C immediately before beginning sampling to shut off the furnace during the test.
- check that all windows, vents, air conditioning, etc. have been closed, for the required time period
- ensure that no smoking, frying or pollutant inducing activities have taken place, and prevent them from taking place for the duration of the testing.
- ensure that no automobiles were operated in attached garages or carports during the previous 18 hours (or since close-up) and that none are operated during the test period
- in homes insulated with UFFI perform a brief inspection to ensure that UFFI is present
- in "reference"homes, perform a brief inspection to ensure that no UFFI is present.

2.3 Ambient Measurements

These measurements are designed to give background information to test results. It is known that results of indoor measurements may be greatly affected by atmospheric conditions as well as certain room air conditions. Consequently, it is essential that these be recorded on the data sheet provided. The measurements required can be divided into two groups; those gathered from the nearest reporting weather office, and those measurements taken on-site.

2.3.1 Weather Office Measurements

a) Barometric Pressure

The nearest weather station to the test site should be contacted for a report of local weather conditions. This information can also be obtained from central reporting stations, but the local station must be specified. Where hourly readings are available, record measurements for the hour most central to the time period over which the house tests were conducted. Data will be recorded on the appropriate provided form.

2.3.2 On-site Measurements

a) Windspeed and direction (using portable anemometer at 1½ metres from the ground). One measurement will be taken upwind of the house as free of nearby obstructions as possible. The anemometer will be operated according to manufacturer's instructions.

b) Outdoor and indoor temperature (in 0°C using dry bulb temperature) taken with psychrometer. One measurement will be taken in the vicinity of each impinger sample at the beginning and at the end of the sample period. The psychrometer will be operated according to manufacturer's instructions.

c) outdoor and indoor relative humidity (using psychrometer) as for b) above.

d) precipitation

e) general weather conditions, eg. sunny, overcast, gusty, etc.

2.4 Fungal Sport Samples

? Fungal growth quantification and identification is significant to this survey in two ~~d~~ways. The growth of fungi in the wall cavity may cause deterioration of the foam and result in the outgassing of formaldehyde. Several fungal spores are known to cause health problems similar to those attributed to formaldehyde gas exposure. All fungal spore samples should be taken prior to drilling holes in the wall.

2.4.1 Fungal Spore Swabs

Swabs for fungal spores are designed to give a sampling of the types of fungi growing in the wall cavity on wood and on the foam. Consequently, swabs should be made of an area under the baseboards whereever possible, and should include a swab of the floor area immediately adjacent to the wall. Ten sample locations should be selected based upon reasonable distribution throughout the house where walls containing UFFI meet the floor. These locations will also be used for wall cavity sampling. The type of floor covering will be recorded on the provided form. If the covering is carpet, a thorough swabbing of fibres is required. A brief description of the swab area and location should be included.

Sterile swabs and sterile containers for the swabs will be supplied by the contractor. After sampling, the ten swabs are to be combined and placed in one sterile container and the container is immediately sealed. The containers are to be delivered to the analyzing laboratory within two weeks. (The name and address of the analyzing laboratory will be supplied to the contractor at a later time.)

2.4.2 Petri Dish Fungal Spore Collection

Airborne fungal spores in the room air of each house will be collected on sterile petri dishes coated with malt agar. The prepared dishes will be supplied by the contractor and will include sampling, packaging and shipping instructions.

Six exposure sites distributed throughout the living space of each house will be selected. Petri dishes should be placed in a "breathing zone" area approximately one and one half metres from the ground. The dishes should then be uncovered for ten minutes. The location of each dish and the duration of exposure should be recorded on the appropriate form.

After exposure, the petri dishes should be immediately covered, sealed and packed in containers cooled with ice-packs. The containers should be kept cooled with ice-packs until delivered to the analyzing laboratory within 5 days of the test. (For the analyzing laboratory see above).

Wherever possible, hand delivery of the fungal spore samples is recommended.

2.5 Wall Cavity Measurements

2.5.1 Formaldehyde and interfering gases measurements

Levels of formaldehyde gas found in wall cavities where UFFI has been installed will give an indication of the rate of outgassing from the foam.

Sample locations will be selected on the basis of presence of UFFI and reasonable distribution of sample sites throughout each home. At least ten such locations will be selected in each home, corresponding to the sites selected corresponding to the sites selected for fungal spores swabs in Section 2.4.1.

- At least one test location should be selected in each UFFI containing wall. [illegible] "wall" [illegible]
- On multi-storey residences, each level must be tested.
- Test locations will be selected wherever possible, so that drill holes are not visible (behind draperies, in closets, behind a flap of wall paper, etc.) [illegible] drill [illegible]
- These locations should be just above the baseboard. [illegible]

To perform wall cavity tests, a power drill with an 11/32" and 1/4" drill bits are necessary. Measurements will be taken using a hand help pump and appropriate range Dräger formaldehyde tube inserted into each hole. Consequently, at least ten low range formaldehyde tubes, and ten high range tubes should be available for use at each site.

Once sample locations have been selected, the following procedure should be followed:

- one hole (11/32") will be drilled at the first site just above the top of the baseboard. Drill a hole in the wall such that the drill bit enters into the area filled with foam. The drilled hole should be of a diameter such that when the detector tube is inserted into the hole, there is a snug, but not tight, fit between it and the wall. Ensure the hole is deep enough so as not to plug the end of the detection tube when it is inserted. The hole should be immediately covered over with a piece of tape and removed only when samples are being made through the hole.

- Before each series of measurements, test the pump for leaks by inserting an unopened tube into the pump and activating the air drawing mechanism. Wait about 1 minute. A leaking pump will open during this test. If the pump does not leak, proceed.
- Break off the tip of a Dräger Formaldehyde 0.5/a tube. Bend the tube in the middle ensuring that the central reagent containing ampoule is broken and insert tube in pump and open end of the tube into the hole in the wall. Operate the pump according to manufacturer's instructions, (Appendix A contains these instructions.
- If the indicating layer turns pink on the first pump, discontinue the test and repeat the procedure with the higher range Dräger formaldehyde tube 0.002 (range 2-40 ppm), or other manufacturer's formaldehyde tube. When the test is finished, replace the tape and record the results. In dimly lit areas a battery-powered lantern should be used to allow proper reading of the detector tube. Ensure that the tubes are stored at temperatures between 0 and 40°C, humidity between 20 and 90%RH, and are kept away from children (corrosive contents). Tubes cannot be used again even after negative test results.
- In some cases the detector tube will be spoiled by interfering gases. This can be readily detected as a yellow to brown discolouration of the tubes. These gases are generated by decomposition of the UFFI, which is normally most advanced in moist areas near the base of the wall cavity. Therefore, the cavity test should be repeated at a test hole higher up in the cavity, about 1½ metres from the floor.

- Should discolouration continue, samples should be taken to quantify the interfering gas at the lower location where yellow to brown discolouration occurred, as follows:
  - i) Dräger ammonia tube 5a(5-70ppm) or 25/a (25-700 ppm) as appropriate to concentration and as many as necessary but not more than 10 samples should be taken, following the same procedure described above.
  - ii) Not more than two impinger collected samples as described in Section 2.5.4.

2.5.2 Water vapour measurements

- break off the ends of a water vapour tube; insert in the pump and insert open end into the wall cavity.
- operate the pump according to manufacturer's instructions to draw air through the tube. Record the length of the reddish-brown stain in terms of mg H_2O/litre, as marked on the tube, on the provided form.
- if water mist is present in the tube, repeat the measurement. If it persists, record this and proceed to the next step.
- remove the tube from the wall and cover the hole with the tape while preparing for wood moisture content measurement.

2.5.3 Wood moisture measurements

- At each test location, perform a wood moisture content measurement of a stud using the following procedures.

The moisture content of wood studs in contact with UFFI in stud spaces will be measured to estimate the amount of moisture retained in that space due to the UFFI. High wood moisture levels provide an ideal environment for the growth of fungi which contribute to the deterioration of both the wood and the insulating material.

The primary concern related to damp wood is associated with fungal growth and weakening of the structure.

The development of fungi on wood is largely controlled by the moisture content. However, if there should be insufficient moisture after growth has started, the fungi may not die, but remain dormant. Growth can re-occur years later if sufficient moisture returns.

For this test a resistance type moisture meter will be used. Instrument description and backgroud information on wood moisture content is contained in the publication, "Moisture Content CorrectionTables for Resistance-type Moisture Meters" by M.Y. Cech and F. Pfaff, published by Department of the Environment Canadian Forestry Service, Forestry Technical Report 7, Ottawa, 1975.

Moisture content measurements should be made in approximately the same locations as wall cavity measurements. Consequently, at least ten of these measurements will be made in each home (except in reference homes where none will be made).

If an area is suspected of being particularly wet, this area should be tested in addition to the standard sampling locations. Exposed wood framing (in the basement) can also be inspected for staining. As wood decays, there is a distinctive mushroom odour. Some wood-rotting fungi produce characteristic aromatic or sweet smells.

Wall studs or baseplates should be sampled for moisture content.

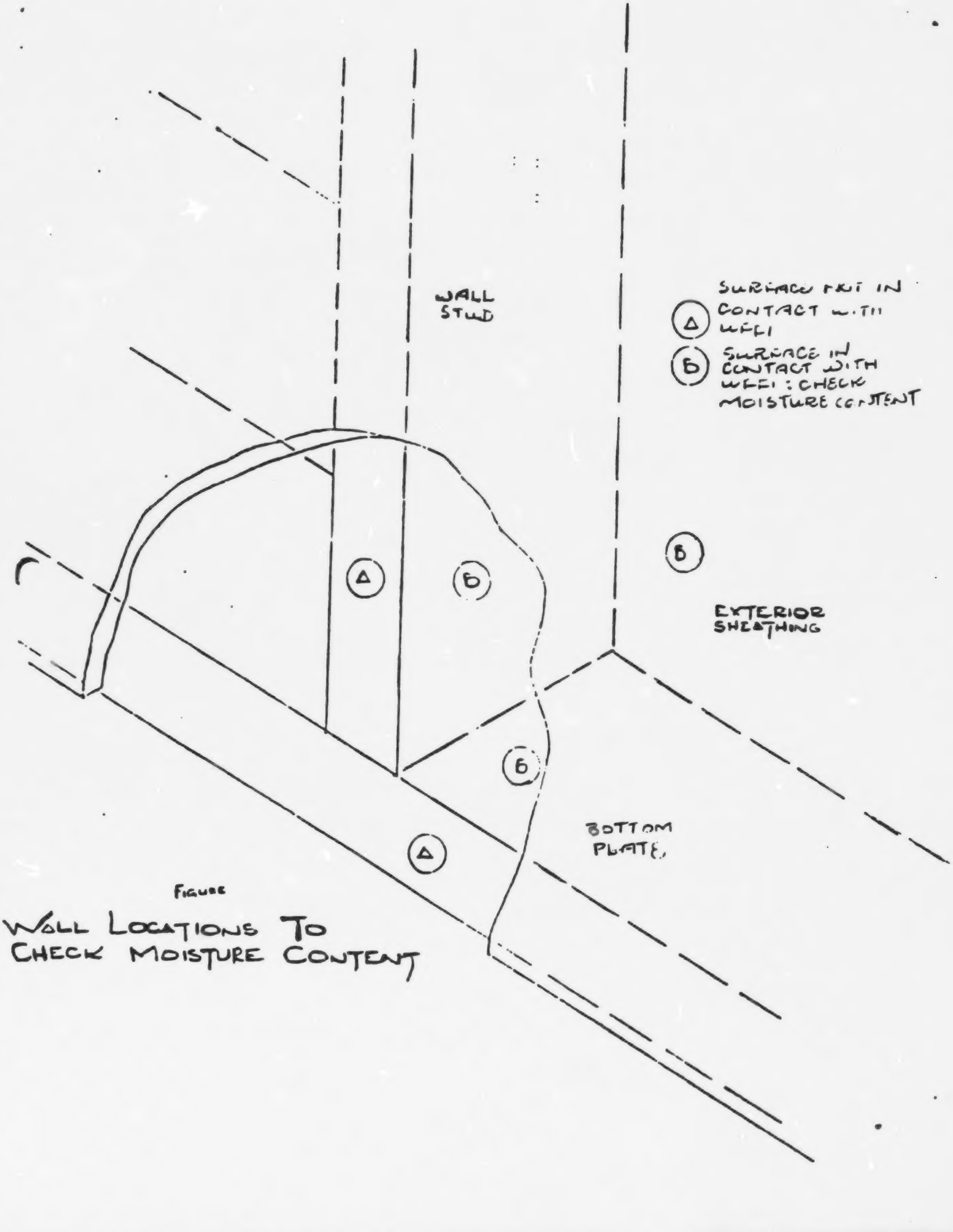
The moisture meter will be used following manufacturer's instructions.

When inserting the probes of the moisture meter into the wood, it must be ensured that the surface has been in contact with UFFI. Make sure that probes are inserted as far as possible into the wood.

Wherever possible, the side of the stud should be approached from the location in which Dräger tube wall cavity samples were taken. (See figure 1). Holes (1/4") made by the moisture meter probes should be repaired on completion of the testing.

Record the readings on the appropriate provided form.

If further measurements are to be made through the hole, cover it with tape. A dowel or plug should be installed in the hole to prevent air flow between the cavity space and interior. In most cases the hole will be sealed permanently (re-drill if measurements are repeated) with a wall plaster such as "Polyfilla". or filler Again, ensure that the entire hole is sealed such that air flow is prevented from passing from the cavity space and the homeowner is to replaster the holes in a few days to cover any gaps due to shrinkage of the filler.


WALL STUD
Ⓐ SURFACE NOT IN CONTACT WITH WFFI
Ⓑ SURFACE IN CONTACT WITH WFFI : CHECK MOISTURE CONTENT
Ⓐ
Ⓑ
Ⓑ
EXTERIOR SHEATHING
Ⓑ
BOTTOM PLATE
Ⓐ

Figure

WALL LOCATIONS TO
CHECK MOISTURE CONTENT

2.5.4 Interfering Gases, (Aldehydes only) Impinger Collected Samples

Impingers, as described in Section 2.6, will be used in the collection of interfering gases samples. An absorbing solution will be prepared and stored in tightly sealed glass bottles. Wherever possible, transport of large quantities of the absorbing solution will be avoided due to the hazardous nature of some of the components.

Aqueous 2,4-dinitrophenyl/hydrazine solution should be prepared as required and the unused portion should be discarded after 3 days. It should be refrigerated, at all times other than during sampling. An example of solution mixing proportions follows:

To a 1-L volumetric flask add 163 ml concentrated HCl and 2.5 g DNPH crystals; this amount of DNPH yields 1 litre of saturated DNPH at 0°C. When conversion to the hydrochloride is complete, orange colour changes to yellow; add distilled water to the 1-L mark. Stopper the flask and agitate by ultrasonic generation to speed solution of solids. The solution will be stored at 5° to 10°C and unused portions will be discarded after three days.

A 1-L mixture of 900 ml cyclohexane and 100 ml iso-octane should be prepared in a volumetric flask and stored in a tightly sealed glass bottle. The mixture is flammable and should be stored and handled accordingly.

Impingers will be filled by pipetting 10 mls of the aqueous DNPH solution into a clean prepared impinger. Ten mls. of the organic mixture will then be pipetted into the impinger. The impinger will then be capped and inlet and outlet tubing will be sealed with parafilm and taped if necessary to prevent air from contacting the absorbing solution. If polypropylene impingers are used, the solid screw caps will be used. The impinger cap and stem should be kept wrapped and clean until it is required.

Upon return to the laboratory, the contents of the impinger will be transferred to a clean Teflon or glass-stoppered glass flask, sealed with Parafilm, and refrigerated until requested for analysis by NRC or a central analytical laboratory. Reference for a possible analytical finish:

Fung and Grosjean,
Analytical Chemistry 53

168-171 (1981)

Location: pump impinger inlets fitted with glass and tygon tubings of minimum possible length will be placed in the lower hole in the wall and the rest of the hole sealed with masking tape. The test is run for 15 minutes.

No more than two of these samples will be taken in each home. If interferences appear in all wall cavity test locations, select two locations which are representative of living space, (eg. one on each floor in a two-storey house).

The flow rate for these samples will be one litre per minute.

2.5.5 Testing Enclosed Floor Space

Measurement of formaldehyde concentrations in one enclosed joist space (per floor) adjacent to an insulated wall is required. An enclosed joist space is the floor framing for the second (or third) floor which normally has wood flooring on top and lath and plaster on drywall attached to the underside (i.e. the ceiling for the first floor). Follow the procedure as outlined above.

[illegible]

2.6. Room Air and Outdoor Formaldehyde Measurements

The procedure to be used for the determination of formaldehyde in air indoors and outdoors, is based upon the NIOSH method P&CAM#125, NIOSH Manual of Analytical Methods, Volume 1, Second Edition, as revised by Lawrence Berkeley Laboratory.

2.6.1 Indoor Sample Locations

Two indoor sample locations will be selected as being representative of room air for each house. These should be in a geometrically central position within the house. For example, in the case of a two-storey dwelling, a sample should be taken on each floor and in a bungalow at each end of the main floor, 24" to 48" from the floor. An appropriate stand to support the impinger securely at this height should be used. If a home occupant complains of a specific problem area, note this and place an impinger there.

2.6.2 Outdoor Sample Locations

An outdoor sample should be taken upwind of the house, as far away from major obstructions and roads or driveways as possible and at least ten feet away from the house. If it should rain during sampling, the impinger inlet should be protected with an inverted metal funnel (crimped opening). An appropriate support for this sampler would be a camera tripod with adjustable legs. The impinger should be positioned at a height equivalent to that of the main floor level of the house.

The analytical method has recently been revised by Robert Miksch at the Lawrence Berkeley Laboratory and the full text of this revised method, approved by NIOSH, with minor revisions specific to this application, is reproduced in Appendix B-1.

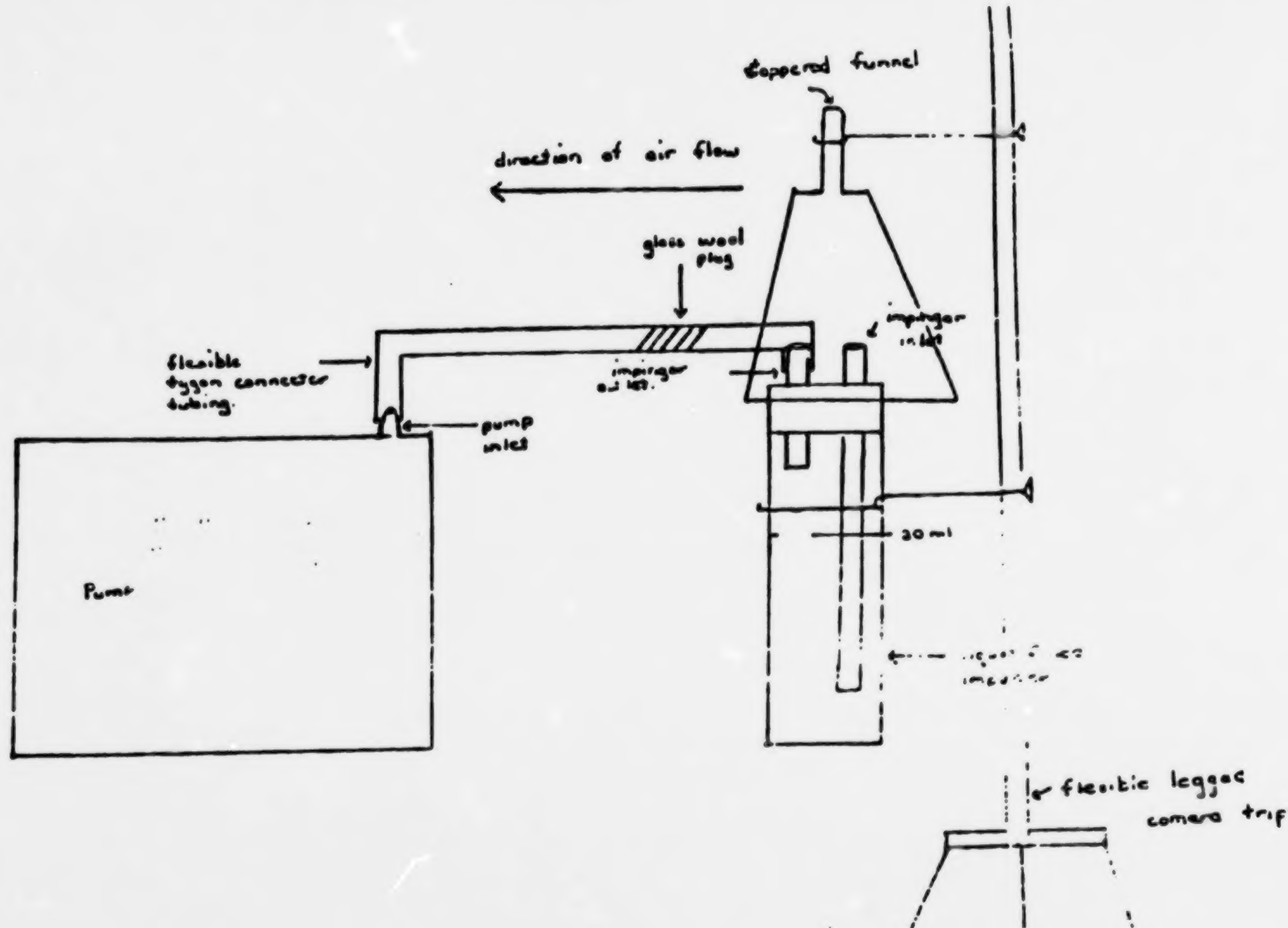

tapered funnel
direction of air flow
glass wool plug
impinger inlet
flexible tygon connector tubing
impinger outlet
pump inlet
30 ml
Pump
liquid in the impinger
flexible legged camera tripod.

Figure : Schematic of outdoor impinger collection setup

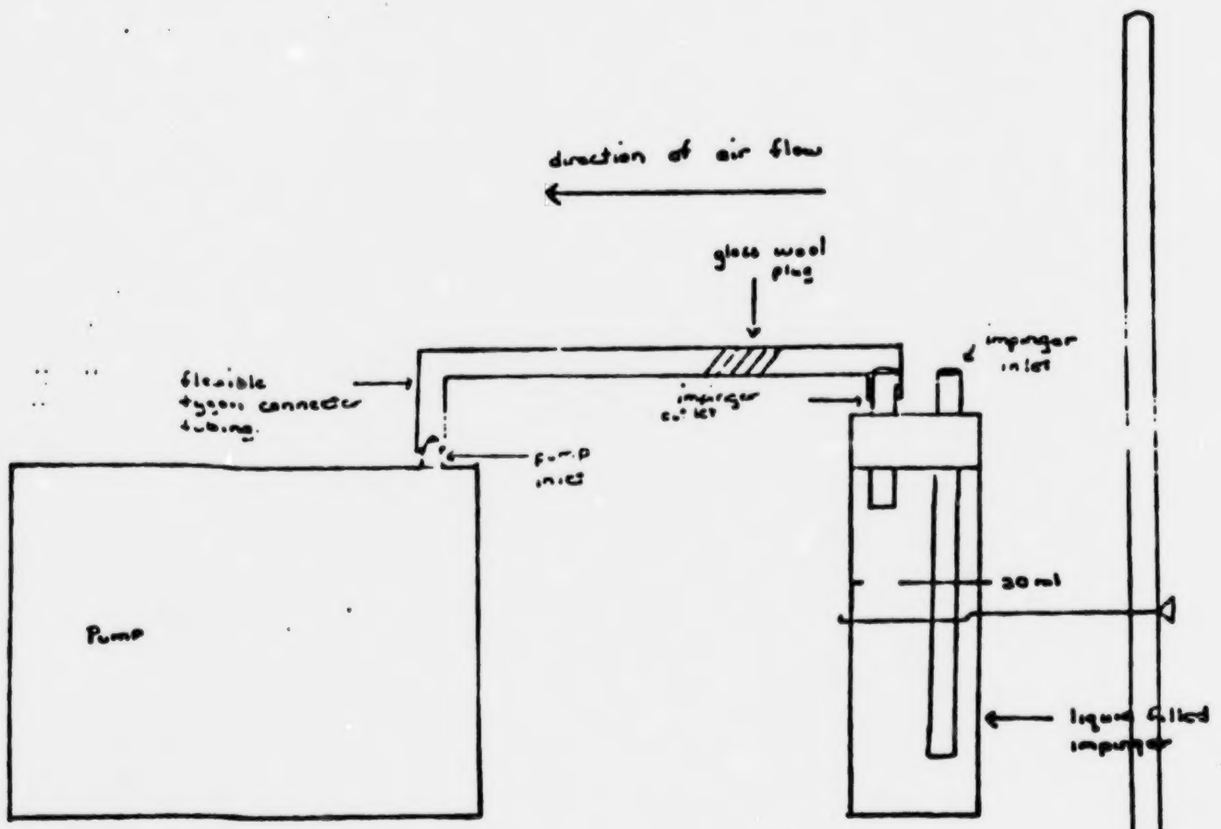

direction of air flow
glass wool plug
impinger inlet
flexible tygon connector tubing.
impinger outlet
pump inlet
30 ml
Pump
liquid filled impinger

Figure : Schematic of impinger collection setup.

2.6.3 Impinger Preparation

Sodium Bisulfite Absorbing Solution (1 per cent) will be prepared by dissolving 1 g of sodium bisulfite in 100 ml of distilled water. This solution will be discarded after one day if not used. An extra supply of the solution plus a clean 20 ml pipette will be available in the field.

Impingers will be well cleaned after each use. If glass impingers are used, they should be cleaned in the same way as other glassware. No rubber should be used in the assembly.

The impinger will normally be loaded with the solution just before the sampling test. If the impinger can be transported from a central office to the test location safely, without agitation, it may be prepared at the central office before the test.

Into a clean, dry impinger measure in 20 ml of the 1 % sodium bisulfite solution using a clean 20 ml pipette.

Impinger outlet and inlet openings should be firmly sealed off with parafilm and taped down if necessary. Impingers preapred in this way, should be carefully packed in an upright position.

2.6.4 Sample Duration

To determine the appropriate sample duration, a low range Dräger tube sample should be taken in the inside location where a NIOSH test will be made. If the concentration read from the Dräger tube is > 2 ppm, NIOSH sample duration is 1 hour

0.5-2 ppm, NIOSH sample duration is 2 hours

< 0.5 ppm, NIOSH sample duration is 3 hours.

One such Dräger 'range' test per house should suffice.

Sample duration of outdoor samples will never be less than three hours.

2.6.5 Sampling Procedure

2.6.5.1 Apparatus

The sampling unit for the impinger collection method consists of the following components:

a straight tube midget impinger containing the absorbing solution of reagent. Glass impingers with ground-glass joints are available from Ace Glass Company. Preferably, impingers should be constructed from teflon tubing, polypropylene centrifuge tubes (VWR #60817-325) and two-holed caps (Bel-Art #F19920). The sample pump is protected from splashover or water condensation by an absorption tube loosely packed with a plug of a glass wool and inserted between the exit area of the impinger and the pump.

- an integrating volume meter such as a dry gas or wet test meter, for calibration of the pump.
- stopwatch
- spectrophotometer or colorimeter: an instrument capable of measuring the absorbance of the colour developed solution using 1 cm cell.
- associated laboratory glassware

2.6.5.2 Temperature and Relative Humidity

As previously mentioned, a temperature and relative humidity measurement will be taken at the beginning and end of the sample period in the vicinity of each indoor and outdoor sample site. The average of the two remperature measurements will be used in the calculation of formaldehyde concentration.

2.6.5.3 Cleaning of Equipment

Care must be exercised to ensure the absence of probable contaminants like organic materials that can be charred by concentrated sulfuric acid. Soaking glassware for one hour in a 1:1 mixture of nitric and sulfuric acids, followed by thorough rinsing with double-deionized water will remove all possible organic contaminants. Polypropylene containers will be washed, double deionized water followed by an absorbing solution wash.

2.6.5.4 Collection and Shipping of Samples

Pour 20 ml of the sodium bisulfite absorbing solution into a straight-tube midget impinger or polypropylene impinger. Connect the impinger to the vacuum pump (via the glass wool-filled tube) with short flexible tubing. The air being sampled should not be passed through any tubing or other equipment before entering the impinger.

A simple impinger containing sodium bisulfite has a collection efficiency of virtually 100 % under the conditions of sampling. Turn on pump to begin sample collection. Care should be taken to measure the flow rate, time and/or volume as accurately as possible and record these on the provided forms. The sample should be taken at a flow rate of 1 1 pm. Duration will depend on expected concentration (See section 2.6). These conditions give a total of from 60 litres to 180 litres of air that is drawn through the system.

After sampling, impinger stem is removed and cleaned. Tap the stem gently against the inside wall of the impinger bottle to recover as much of the sampling solution as possible. Wash the stem with a small amount (1-2 ml) of unused absorbing solution and add the wash to a labelled prepared polypropylene transfer bottle.

The liquid in the impinger should then be transferred carefully to the transfer bottle. A small amount (1-2 ml) of excess absorbing solution should be used to wash out the impinger and this wash should be added to the labelled transfer bottle. The bottle should then be capped with a screw cap. No rubber should be used. Impingers constructed from polypropylene centrifuge tubes will be sealed directly with solid plastic closures (VWR #60817-540), alleviating the need for a transfer bottle.

Care should be taken to minimize spillage or loss by evaporation at all times.

Whenever possible hand delivery of the samples is recommended. Otherwise, samples should be carefully packed to avoid spillage. A "blank" impinger should be handled as the other samples (fill, seal and transport) except that no air is sampled through this impinger.

Each sample team should prepare one blank per house sampled.

NOTE: The samples and blanks will be delivered to the laboratory as quickly as possible, preferably the same day as testing. If a delay occurs in delivering the samples they should be kept cool using refrigeration or ice packs. At room temperature, samples in 1% Na HSO_3 are stable for at least 2 weeks, but elevated temperatures experienced in storage or transport may drive off some of the formaldehyde. Take care to minimize spillage or loss by evaporation.

2.7 Passive Dosimeters

Passive dosimeter devices will be used in several situations in the course of this study. The devices are designed for the most part, to quantify average exposure to formaldehyde gas for a period of up to one week.

2.7.1 Passive DuPont Dosimeters

A passive DuPont device will be exposed for a period of one week in each home. This device will give an indication of average formaldehyde gas levels in a house. [illegible]

MONITORING INSTRUCTIONS

- The sampling temperature range should be between 40°F and 120°F (4°C to 49°c).
- Do not open the pouch until you are ready to use the badge. Hold the pouch right side up. Open the foil-lined pouch by cutting along the designated line. The badge is activitated as soon as the pouch is opened.
- Remove the badge from the pouch. Do not handle the diffuser.
- Use the sticker proved to record: provided
    - a. user identification
    - b. date
    - c. start time
    - d. test environment temperature
    - e. test environment relative humidity (if desired)

- Record the appropriate data on the provided form (Appendix D)
- Place the completed identification sticker on the empty pouch, which will be used to store the badge after exposure.
- Affix the badge number, which corresponds to the number on the identification sticker,to the badge.
- Suspend the badge at about 48" from the floor, allowing air to pass freely around the sampler.
- Instruct the home occupant to keep the room in which the sampler is suspended free of pollutant creating activities - smoking, cooking, etc. for the duration of the test (1 week).
- The home occupant should be instructed to follow these procedures at the end of the week long sampling
- After exposure, record the end time and total exposure time on the identification sticker, and complete the provided form. Send one copy of the form with each badge.
- Insert the badge in the pouch and seal, using the closure provided. Sealing will prevent further exposure.
- Actual shipping instructions and shipping locations will be supplied prior to the commencement of the test program.

The sampler location will be selected on the basis of the following criteria:

- A room with two or more walls containing UFFI will be selected where possible
- The room will be closed off for the duration of the sampling
- The sampler will be located centrally at a height of approximately 48" from ground and suspended in such a way as to prevent obstruction to air movement around the sampler.

2.7.2 Other Passive Devices

Oak Ridge National Lab and Detectronics passive devices are being considered for testing and comparison and may be provided for use in approximately 250 of the 2300 homes. In most cases this will require a similar amount of technician time and effort as the DuPont dosimeters described in Section 2.7.1.

2.8 Reference Homes

Approximately one out of every six homes tested will not be a UFFI insulated home. These homes will serve as references in comparisons of test results. Tests conducted in these homes will be performed in exactly the same way as those performed in UFFI insulated homes. A comparison of procedures required in each type of home is contained in Table 2 below:

TABLE 2

Procedure	UFFI Homes	Reference Homes
meterological data	X	X
house preparation	X	X
questionnaire	X	X
wall cavity tests	X	No
interfering gases tests	X	No
NIOSH samples (room)	X	X
NIOSH sample (outside)	X	X
windspeed and direction	X	X
indoor temperature and R.H.	X	X
wood moisture	X	No
fungal spore swabs	X	X
petri dish samples	X	X

2.9 Quality Control/Quality Assurance

The terms quality control and quality assurance are often used interchangeably, but they have distinct meaning. Quality control is used here to refer to the day-to-day routine checks on internal chemical analysis results (replicate analysis etc.), for example. Quality assurance is used to denote a system of documentation, operating procedures, etc. that prescribes how project or product specifications are to be accomplished and also refers to external references testing, for example, interlaboratory quality control indicates whether or not the specifications have been met (within certain limits of accuracy and precision). Quality assurance anticipates the causes of error and imprecision and attempts to alleviate them through careful attention to explicit protocols.

A program of QC/QA procedures based upon an accompanying document will be applied to the survey.

2.9.1 Quality Control - Sample Collection Methods

2.9.1.1 Replicate Samples

Replicate sampling is a means of determing variations induced by the sampling method in the field. Replicate sampling is recommended for sampling methods by which few samples are taken in each house and for which a known degree of precision is important. Included in this category are room air samples for formaldehyde (both the NIOSH method, LAwrence Berkeley revision, and the passive monitors, DuPont), and for intefering gases (#123 Standard Methods of Air Sampling and Analysis).

Replicate sampling is not recommended for those sample parameters which, by their nature, may be expected to show large inter-sample variations even on a side-by-side sampling basis. Included in this category are fungal spore samples, and wall cavity samples for wood moisture and formaldehyde. The large numbers of samples of these parameters to be taken in each house will establish a range of values for that house. Individual sample precision is not considered to be so critical in these cases.

Replicate sampling is to be done on 10% of the air samples for formaldehyde (NIOSH-revised method), 5% of the air samples for formaldehyde (passive monitors-DuPont method), and 10% of air samples for interfering gases. The total number of specified samples and replicates for 2,300 homes is therefore:

	Samples Specified Per House	Total Specified	Survey Replicates
Formaldehyde in air (NIOSH - revised)	3	6,900	690
Formaldehyde in air (passive - DuPont)	2	4,600	460

The location for replicate sampling of formaldehyde in air are to be assigned using a random numbers table and the house identification numbers previously assigned. For example - enter a random numbers table randomly; four place numbers are needed, so four digit columns should be used; if the number is 2,300 or less, assign the house with that number a replicate sample; if the number if greater than 2,300 or repeats pass on to the next.

The location for replicate sampling of interfering gases are assigned to project teams as a sequential house number in which the sampling is required (5th, for example).

2.9.1.2 Sample Blanks

Requirements for sample blanks are as follows:

PARAMETER	BLANKS RECOMMENDED
Formaldehyde in air (NIOSH-revised)	1 per home
Formaldehyde in air (passive DuPont)	2% of samples
Fungal spore swabs	1 per home
Fungal spore plates	1 per home
Interfering gases	1 per home

Assuming the 2,300 homes are tested at a rate of two per field team day, the anticipated total number of samples, replicates and blanks are as follows:

Parameter	Samples Specified per House	Total Specified	Replicates	Blanks
Formaldehyde in air (NIOSH - revised)	3	6,900	690	2530
Formaldehyde in air (passive DuPont)	1	4,600	460	92
Interfering gases (impinger)	- as needed	-	-	1/home
Ammonia in wall cavity (detection tube)	- as needed	-	-	-
Formaldehyde in wall cavity (Dräger)	10	23,000	-	-
Relative humidity in wall cavity (Dräger)	10	23,000	-	-
Wood Moisture	≥ 10	23,000	-	-
Fungal spore swabs	10	500	-	500
Fungal spore plates	6	3,000	-	500

2.9.1.3 Sample Identification

Replicate and blank samples will be labelled such that they are indistinguishable from specified field samples. Similarly, no indication of these will be given to the analytical laboratory on the data sheets accompanying the samples to the laboratory. Only the field data sheets which are sent to the local supervisor and project manager will record the sample designations.

2.9.2 Data Recording and Transmissal

Data collected in the field will be recorded upon data sheets similar to those following in this section. The data sheets are designed to contain relevant field information for the project records. They consistute a check to ensure all appropriate monitoring tasks are done, questions are asked, and observations are made. Therefore, all data sheets are to be filled in by the field team, or explanation given for incomplete date. Every data sheet requires the signature of the field team. supervisor/manager.

The data sheets indicate the route of transmissal for the various kins of information. A summary checklist of sampling done in each house provides that information for the homeowner, as well as for the local supervisor's identification of houses and the project manager's records of progress. A field data sheet for formaldehyde in wall cavities and room air provides sampling details necessary for calculating and validating results to the local supervisor and project manager.

The analytical laboratory receives from the field team only a list of sample numbers on the lab reporting sheet. The lab returns the results on a copy of the same sheet to the local supervisor and project manager. The other sample data sheets included in this section are self explanatory. Together, they constitute a work package for each house.

APPENDIX A

MANUFACTURER'S INSTRUCTIONS

DRÄGER PUMP

DRÄGER FORMALDEHYDE TUBES

The instruments described here are used to measure formaldehyde concentrations in air at levels above approximately 0.5 ppm. As such, they are useful for measuring formaldehyde in the Wall Cavity Air Sampling procedure or for spot checks in areas where high levels of formaldehyde are suspected.

The instrument in most common use is of the detector tube type, such as the Dräger or Gastec system. Although a detailed explanation of detector tube usage is outlined here, the manufacturer's instructions accompanying the equipment should be consulted before usage.

DRAGER TUBE DETECTION SYSTEM

This system utilizes a detector tube and calibrated air sampling pump to determine formaldehyde vapour levels in the air. The assembled apparatus consists of the gas detector bellows pump, a stroke counter and the Dräger Tube as shown in Figure A-1.

In most cases, the detector tube known as Dräger Tube, Formaldehyde 0.5/a will be used. This tube is designed for measuring formaldehyde vapour levels in air in the range of 0.5 to 10 ppm. If an air sample reading is at the upper limit of this range, a higher range Dräger Tube (Formaldehyde 0.002; 2-40 ppm) should be used.

The gas detector pump is a hand-operated bellows pump. This pump supplies 100 cm^3 with each stroke. Thus, not only does the gas detector pump suck in the gas sample, but it also simultaneously carries out a volume measurement with each stroke. Its mode of operation is, therefore, that of a dosage pump.

The gas detector pump bellows is made from neoprene and opens automatically after compressing and releasing the bellows. This opening process is effected by two steel springs built into the pump. The end of the suction process is reached when the limit chain is taut.

The gas detector pump has only one valve, which is closed when the gas sample is sucked in and opens again on squeezing the bellows. The pump head has an aperture into which the Dräger Tube to be used is inserted.

The counter accessory records the number of pump strokes, so that the operator need not remember the count (see below.)

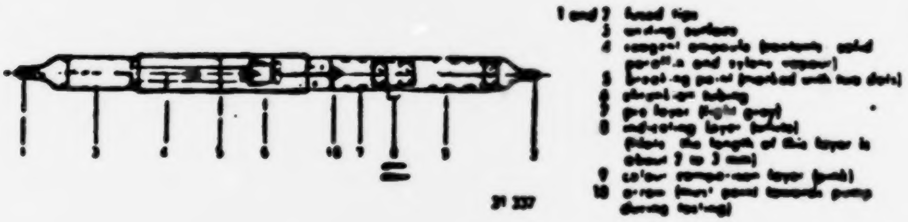
MEASUREMENT PROCEDURE

1. Before each series of measurements, test the pump for leaks. This may be done by inserting an unopened tube into the bellow pump head and squeezing the bellows. A leaking pump will open during this test (wait for about 1 minute).
2. Break off the tips of the Dräger Tube
3. Bend the Dräger Tube at the points marked with two black dots, so that the inner ampoule breaks. The shrunk-on tubing holds the parts of the tube together. Inspect to make sure that the ampoule has broken.

4. Insert the Dräger Tube tightly in the pump head (arrow points towards the pump).

5. a) 0.5/a Formaldehyde Tube:

   Suck the air sample through the Dräger Tube (count the pump strokes) until the white indicating layer (Figure E2) has turned a pink colour which corresponds approximately to the pink comparison layer.


1
3
4
5
6
10
7
8
9
2
39 337
1 and 2 head tips
3 sealing surfaces
4 reagent ampoule (contents: acid, paraffin and xylene vapour)
5 breaking point (marked with two dots)
6 plugged-on tubing
7 pre layer (light grey)
8 indicating layer (white) (Note: the length of this layer is about 2 to 3 mm)
9 colour comparison layer (pink)
10 arrow (must point towards pump during testing)

The formaldehyde concentration results from the number of pump strokes necessary for colour comparison in accordance with the following table:

Number of Strokes	Formaldehyde (ppm)
16	0.5
13	0.7
10	1
7	1.5
5	2
3	4
2	7
1	10

5. b) 0.002 Formaldehyde Tube

This tube is used differently than the low range tube above. The pump is operated for five (5) strokes and a reading is taken directly off of the calibrated scale on the tube. The length of the colour change corresponds to the formaldehyde levels.

Precautions

Caution should be exercised when sliding the detector tube out of the test hole to ensure that the plastic sleeve holding the broken tube together does not pull off.

The discolouration persists for a few hours if the tubes are sealed with rubber caps. The tubes cannot be used again even after a negative test result.

The Dräger Tubes can be used in a temperature range of from 0°C to 40°C. Humidity has no influence on the indication between 3 and 15 mg. H_2O per litre.

Do not allow the Dräger Tubes to fall into the hands of children as the contents are corrosive.

If interfering gases prevent proper sample readings, report the measurement through a test hole drilled into the upper area of the stud space.

Comments on Interferences - How to Record Data

Similarly detailed instructions are provided with each box of each type of indicating tubes. These manufacturer's instructions should be followed vigourously.

APPENDIX B

ANALYTICAL PROCEDURES

B-1 Sodium Bisulfite Collected Formaldehyde

B-2 DuPont Passive Badge Type C-60

B-3 Detectronics

APPENDIX B-1

REVISED NIOSH PROCEDURES METHOD

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(with minor revisions added)

There has been concern recently that gaseous formaldehyde may be emitted from consumer products containing urea-formaldehyde resins. Substantiating data compiled by researchers has generally been based on the use of the NIOSH chromotropic acid procedure. An examination of the data, however, show that there have been significant variations in the actual procedure applies, particularly in the areas of sampling and calibration. The variations arise from two causes: (1) the NIOSH procedure fails to completely specify many experimental details, and (2) in some areas new knowledge has shown ways in which the procedure might be improved.

Presented below is a procedure which can be applied in a standard manner, without deviations, under a wide range of conditions. Where necessary, experimental details of the NIOSH method have been explicitly defined. Improvements designed to reduce the errors associated with sampling and calibration has been incorporated, yet the central method of analysis has been left virtually unchanged in order to reain the validity of the NIOSH procedure. Use of the following procedure should reduce error, simplify measurements, and facilitate the correlation of data.

1. Principle of the Method

1.1 Formaldehyde reacts with chromotropic acid-sulfuric acid solution to form a purple monocationic chromogen. The absorbance of the colored solution is read in a spectrophotometer at 580 nm and is proportional to the quantity of formaldehyde in the solution . (References 11.3, 11.8).

2. Range and Sensitivity

2.1 Form 0.25 ug/ml to 5.0 ug/ml of formaldehyde can be measured in the absorbing solution.

2.2 A concentration of 0.1 ppm of formaldehyde can be determined in a 60 liter air sample based on an aliquot of 4 ml from 25 ml of absorbing solution and a difference of 0.05 absorbance unit from the blank.

3. Inteferences

3.1 The chromotropic acid procedure has very little interference from other aldehydes. Saturated aldehydes give less than 0.01 percent positive interference, and the unsaturated aldehyde acrolein results in a few percent interference. Ethanol and higher molecular weight alcohols and olefins in mixtures with formaldehyde are negative interferences. However, concentrations of alcohols in air are usually much lower than formaldehyde concentrations and, therefore, are not a serious interference.

3. 3.2 Phenols result in a 10 to 20 percent negative interference when present at an 8:1 excess over formaldehyde. They are, however, ordinarily present in the atmosphere at lesser concentrations than formaldehyde and, therefore, are not a serious interference.

3.3 Ethylene and propylene in a 10:1 excess over formaldehyde result in a 5 to 10 percent negative interference and 2-methyl-1, 3-butadiene in a 15:1 excess over formaldehyde showed a 15 percent negative interference. Aromatic hydrocarbons also constitute a negative interference(Reference 11.8). It has recently been found that cyclohexanone causes a bleaching of the final colour (Reference 11.5)

3.4 Nitrate anion in a 6:1 excess over formaldehyde can result in a 50 percent negative interference. Nitrite anion at the same concentration can result in a 20% negative interference. These anions can result from NO_2 absorbtion into water according to the equation.

$$2\ NO_2 + H_2O \longrightarrow HNO_3 + HNO_2$$

The average collection efficiency of water for NO_2 is about 20 percent (Reference 11.2). Concentrations of NO_X are particularly high in air samples from combustion sources.

4. Precisions and Accuracy

The original NIOSH method was checked for reproducibility by havein three different analyses in three different laboratories analyze standard formaldehyde samples. The results listed in Table 1 agreed with ± 5 %.

TABLE 1

COMPARISON OF FORMALDEHYDE RESULTS FROM THREE LABORATORIES

Micrograms Formaldehyde	Absorbance		
	Lab 1	Lab 2	Lab 3
1	0.057	0.063	0.061
3	0.183	0.175	0.189
5	0.269	0.279	0.262
7	0.398	0.381	0.392
10	0.566	0.547	0.537
20	1.02	0.980	1.07

The revised NIOSH method presented in this work by and large offers techniques that will reduce the errors associated with sampling and standardization. Thus, the precision and accuracy of formaldehyde determinations is substantially improved even though the reproducibility of the analysis itself remains virtually unchanged.

7.1 Reagents

Chromotropic Acid Reagent

Dissolve 0.10 g of 4,5-dihydroxy-2, 7-naphthalenedisulfonic acid disodium salt (Eastman Kodak Company, Rochester, New York, Cat. No. F230) in water and dilute to 10 ml. Filter if necessary and store in a brown bottle. Makeup fresh weekly.

7.2 Concentrated sulfuric acid, reagent grade.

7.3 Formaldehyde Standard Solution "A" (1 mg/ml)

Sodium formaldehyde bisulfite (Fischer Scientific or Eastman Kodak Company, Cat. No. P6450), is used as a primary standard (Reference 11.4). Dissolve 4.4703 g in distilled water and dilute to 1 liter.

7.4 Formaldehyde Standard Solution "B" (10 ug/ml)

Dilute 1 ml of standard solution "A" to 100 ml with 1% sodium bisulfite solution. Make up fresh daily.

7.5 Sodium Bisulfite Absorbing Solution, 1 %

Dissolve 1 g of sodium bisulfite in 100 ml of distilled. This solution should be prepared daily and discarded if not used.

7.6 Sodium Sulfite Solution, 0.1 (approximate)

Dissolve 12.6 g of sodium sulfite in 100 ml of distilled water. It is best to prepare a fresh solution weekly.

ANALYSIS

8.3.1 Transfer the sample from each impinger to a 25 ml volumetric flask. Make up to 25 ml with 1% $NaHSO_3$ solution.

8.3.2 Pipette a 4 ml aliquot from each of the sampling solutions into glass stoppered test tubes. A blank containing 4 ml of 1% $NaHSO_3$ must also be run. If the formaldehyde content of the aliquot exceeds the limit of the method, a smaller aliquot diluted to 4 ml with 1 % $NaHSO_3$ is used.

8.3.3 Add 0.1 ml of 1 % chromotropic acid reagent to the solution and mix thoroughly.

8.3.4 To the solution pipette slowly and cautiously 6 ml of concentrated sulfuric acid. The solution becomes extremely hot during the addition of the sulfuric acid. If the acid is not added slowly, some loss of sample could occur due to spattering. Mix the solution thoroughly after the addition, using a vortex mixer.

8.3.5 Heat the mixed solution on a boiling water bath for 15 minutes. Allow to cool to room temperature. Read at 580 nm in a suitable spectrophotometer using a 1 cm cell. No change in absorbance was noted over a 3 hour period after color development Determine the formaldehyde content of the sampling solution from a curve previously prepared from standard formaldehyde solution.

9 Preparation of Standard Curve

9.2.1 Six standard solutions shall be prepared daily from Solution B, by pipetting 0.5, 1.0, 2.0, 3.0, 4.5, 6.0 mL into 25 ml. volumetric flasks in series. These are to be made up to 25.0 mL with the fresh 1% $NaHSO_3$. Four millilitre aliquots of the six fresh standard solutions and a lab blank are to be run with every set of samples.

9.2.2 Develop the colour as described in the analysis procedure (Section 8.3).

9.2.3 Plot absorbance against micrograms of formaldehyde in the colour developed solution.

10 CALCULATIONS

10.1 Convert the volume of air samples (V) to the volume of air at standard conditions (V_s) of 760 mm of mercury and 25°C using the correction formula:

$$V_s = V \times \frac{P}{760} \times \frac{298}{(T + 273)}$$

where:

V_s = volume of air in litres at standard conditions

V = volume of air samples in litres

P = barometric pressure in mm of mercury

T = temperature of sample air, °C

10.2 Determine the total concentration (C_t) of formaldehyde present in the sample impinger.

$$C_t = C_A \ X \ F_A$$

where:

C_t = total pg. of formaldehyde in the sample

C_A = formaldehyde concentration in pg of the sample aliquot taken from impinger A. as determined from the calibration curve

F_A = aliquote factor: $\frac{\text{sampling solution volume in ml}}{\text{ml aliquot used}}$

$$= \frac{25 \text{ ml}}{4 \text{ ml}}$$

$$= 6.25$$

10.3 The concentration of formaldehyde in the sampled atmosphere may be calculated by using the following equation, assuming standard conditions are taken as 760 mm of mercury and 25°C:

$$\text{ppm (volume)} = \frac{C_t \ X \ 24.47}{V_s \ X \ \text{M.W.}}$$

where:

V_s = litres of air samples at standard conditions

M.W. = molecular weight of formaldehyde (30.03)

24.47 = pl of formaldehyde gas in one micromole at 760 mm Hg and 25°C

APPENDIX B-2

ANALYTICAL PROCEDURES FOR FORMALDEHYDE BADGES, SERIES II, TYPE C-60

The PRO-TEK ^{TM} Formaldehyde Badge is a diffusion monitor for collecting formaldehyde samples from the air. The sample is analyzed with a modified chromotropic acid-sulfuric acid test (reference on page 6). This procedure as outlined meets the NIOSH accuracy requirements for an analytical sampling method.

PRINCIPLE

The reaction of formaldehyde with the chromotropic acid-sulfuric acid solution results in a purple color. The absorbance of the solution is read at 580 nM. The absorbance is proportional to the amount of formaldehyde collected in the solution.

RANGE

2-50 ppm-hours

INTERFERENCES

Suspected interferences for formaldehyde badges are the same as the interferences for impingers based on the proven and established method described in NIOSH P&CAM 125:

> "The chromotropic acid procedure has very little interference from other aldehydes. Saturated aldehydes give less than 0.01% positive interference, and the unsaturated aldehyde acrolein results in a few per cent positive interference. Ethanol and higher molecular weight alcohols and olefins in mixtures with formaldehyde are negative interferences. However, concentrations of alcohols in air are usually much lower than formaldehyde concentrations and, therefore, are not a serious interference.

"Phenols result in a 10 to 20 % negative interference when present at an 8:1 excess over formaldehyde. They are, however, ordinarily present in the atmosphere at lesser concentrations than formaldehyde and, therefore, are not a serious interference.

CONCENTRATED SULFURIC ACID

Procedure

Use only fresh, clear H_2SO_4. Ages H_sSO_4 packaged in bottles with Bakelite caps tends to turn yellow and, thus, obscures the colormetric reading. Store H_2SO_4 used for CH_2O determinations in glass-stoppered containers.

Cleaning of Glassware

Glassware should be free of any organic contaminants. Soak all glassware for at least ten minutes in a standard chromic acid cleaning solution (Sodium dichromate in H_2SO_4). Rinse six times with deionized water. Rinse finally with deionized and distilled water.

ANALYSIS INSTRUCTIONS

1. Color Activation

Caution: Concentrated sulfuric acid is highly corrosive!
Do not spill on skin or clothing!
Wear rubber gloves, apron, and eye protection.

The solution will become very hot. Hold the flask by its neck. Hold the pack with the diffuser on the left. Cut an opening in the absorbing solution blister. Pipette 2.0 ml from the pack into a clean, dry 25 ml Erlenmeyer flask. Add 0.3 chromotropic acid. Add 3.0 ml concentrated sulfuric acid slowly. Swirl to ensure complete mixing.

Heat the flask at 90°C to 95°C for 15 minutes, then allow it to cool to room temperature (approximately 30 minutes). Read the absorbance in the spectrophotometer set at 580 nM, using matched 40 mm (4 mm window) rectangular glass semi-micro-cuvettes (see the Appendix). Exposed badge solutions must be read out against a blank (unexposed) badge solution. Pour the solution from the flask into the 40 mm cuvette.

When using any scanning spectrophotometer, approach the desired wavelength from the same direction each time. If you overshoot the specified wavelength, go back in the opposite direction at least 50 nM and come forward again to the desired wavelength. If there is a slit adjustment on your spectrophotometer, make sure the same slit opening is used on all analyses and that the slit is adjusted in the same manner each time.

> "Ethylene and propylene in a 10:1 excess over formaldehyde result in a 5 to 10 per cent negative interference and 2-methyl-1, 3-butadiene in a 15:1 excess over formaldehyde showed a 15 % negative interference. Aromatic hydrocarbons also constitute a negative interference. It has recently been found that cyclohexanone causes a bleaching of the final color."

OVERALL SYSTEM ACCURACY

± 13.9 % (see Laboratory Validation Report for PRO-TEK™
C-60 Formaldehyde Badge).

BADGE SHELF LIFE

Unexposed badges must be refrigerated at 40°F. Their shelf life is six months.

Exposed badges should be tested as soon as possible. Exposed badges can be stored at room temperature for as long as two weeks prior to color activation, although refrigeration at 40°F is preferred. Avoid freezing.

> Note: Although future data may substantiate that formaldehyde badges have a longer shelf life, current recommendations should be followed now.

APPARATUS

Scissors

Pippettes (one per badge)

Spectrophotometer (Perkin-Elmer, Model 552 UV-Visible or equivalent) equipped with long path cell holders (Perkin-Elmer No. 500-0119)
(2) Matched 40 mm rectangular semi-micro-cuvettes (cells)** (available from DuPont)

1 ml Cole-Parmer pipette with disposable tip

25 ml Erlenmeyer flask with ground glass stopper (1/badge)

REAGENTS

1 % chromotropic acid: Dissolve 0.10 gm, 4,4-dihydroxy, 2, 7-naphthalenedisulfonic acid disodium salt (Fisher Scientific Co. Certified ACS C-613, King of Prussia, PA) in deionized and distilled water. Dilute to 10 ml.

Make us a fresh batch weekly.

** Because these cells have a long delivery time, DuPont's Applied Technology Division is temporarily maintaining an inventory (available May 1, 1981) for your convenience.

ANALYSIS INSTRUCTIONS (continued)

Caution: The activated badge solution is very corrosive.
Do not spill on skin or clothing.
Clean spills immediately.
Wear eye protection.

2. Calculations

The absorbance value obtained for the exposed badge solution compared with the blank badge solution, when divided by the calibration factor supplied with each lot of badges, gives the time weighted average (TWA) exposure dose in ppm-hours. This value, divided by the exposure time in hours, gives the TWA exposure in ppm.

Each lot of badges has a calibration factor that is supplied with the badges. The calibration factor has the units of absorbance per ppm-hour exposure. To determine the TWA formaldehyde exposure in ppm, use the following equation:

$$\frac{\text{Absorbance (Sample)} - \text{Absorbance (Blank)}}{\text{Calibration Factor} \times \text{Total Hours Exposed}} = \text{ppm (TWA)}$$

For example:

1. The absorbance of the exposed badge solution read against a blank color activated badge solution - 0.250.
2. The calibration factor for the particular lot of badges found in the box was 0.0440 absorbance units/ppm-hour.
3. The exposure time was 7.5 hours

Calculation:

$$\frac{0.250}{0.0440 \times 7.5} = 0.76 \text{ ppm}$$

REFERENCE

NIOSH Manual of Analytical Methods, HEW Publication No. (NIOSH) 75-121, U.S. Department of Health, Education and Welfare, Public Health Service, Centre for Disease Control, National Institute of Occupational Safety and Health, Division of Laboratories and Criteria Development, Cincinnati, Ohio, P&CAM 125, 1974.

APPENDIX

Item Description: 40 mm rectangular semi-micro-cuvettes (cells)

Specifications: (Matched Pairs)

40 mm light path length

(No less than) 4 mm viewing window

5.2 ml - 5.6 ml capacity

visible optical glass only

funnelled top with cover

frosted sides

45 mm high

12.5 mm wide

40 mm long

APPENDIX B-3

DETECTRONICS FORMALDEHYDE

TEST KIT

The Detectronics Formaldehyde Test Kit consists of three basic parts:

a) Calibrated sampling syringe
b) Detection tubes
c) Color comparison chart

Instructions:

1) Remove the red cap from one of the detection tubes and attach to the calibrated sampling syringe. (Fig. 1)

2) With a pair of pliers, break off and discard the small glass bead at the capillary end of the detection tube. Only the ***tip*** (not more than ⅛ inch) of the capillary should be broken. If the break occurs in the orange or white section, discard the detection tube.

3) Enter the area to be tested and slowly protract (pull out) the syringe plunger untill 60 cubic centimeters (c.c.) of air have been collected (first black ring is on the 60 c.c. mark). Should the plunger move back when released, pull back to the 60 c.c. mark and hold the plunger there for several seconds. To simulate **winter conditions (when formaldehyde concentrations are normally highest)**, close doors and windows in the area to be tested for several hours prior to sampling.

4) Remove the detection tube from the syringe and place in a pre-heated oven at 200° F for approximately 5 minutes.

5) Remove, allow to cool, and examine the capillary end of the detection tube directly in back of the red-orange band. A purple coloration indicates the presence of formaldehyde. At very low concentrations the color change is slight and somewhat difficult to see. Observe against a white background or compare to an unexposed detection tube.

6) To semi-quantitate (determine the approximate amount of formaldehyde present), compare the color in the detection tube to the color comparison chart below. Use artificial light (preferably fluorescent), ***not*** sunlight.

7) Note results and discard the used detection tube in a manner that will prevent spillage of the contents or exposure to children. Other areas may now be tested in a similar manner.

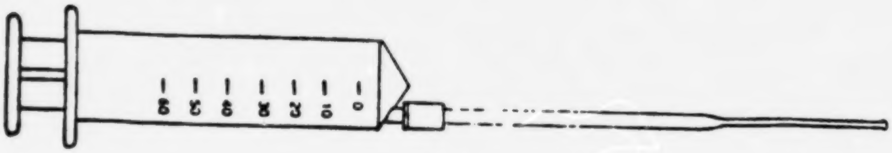
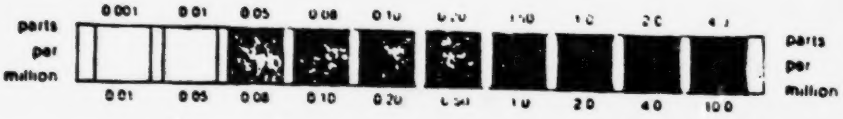


Fig. 1



Color Comparison Chart

If, for any reason, you are dissatisfied with the Detectronics Formaldehyde Detection Kit, return all unused components with a brief explanation of the reason for dissatisfaction for a prompt refund. All materials and workmanship are warranteed by Detectronics, Inc. Your complete satisfaction is our goal.

Since we have no control over the manner in which this product is used, we cannot assume responsibility for misuse or use other than that intended. All guarantees and warranties are void in such cases. Read and follow directions carefully. REFRIGERATE UNTIL USE. DETECTION TUBES MUST BE USED WITHIN 2 MONTHS AFTER RECEIPT OF KIT. New detection tubes are available for $2.00 each.

WARNING: This product contains sulfuric acid. Avoid contact of the formaldehyde detection # space material (white powdery material in the detection tubes) with skin or eyes. Avoid ingestion or inhalation. Clean up any spills promptly with baking soda and water.

Eye contact: flush eyes immediately with water for a minimum of twenty minutes. Seek medical attention.

Skin contact: wash affected area thoroughly with soap and water.

Inhalation or: Ingestion seek medical attention.

APPENDIX C

HOME RESIDENT QUESTIONNAIRE

(SUMMARY)

HOME RESIDENT QUESTIONNAIRE

A home resident questionaire, to be administerd by a technician on site is currently in preparation.

The questionnaire will consist of approximately thirty questions arranged to collect the following supporting information.

1. Personal Data

   The number and ages of occupants and their daytime occupations

2. Health Data

   A listing of a range of likely symptoms and request for information concerning residents' health in relation to these symptoms

3. House Construction

   Details of house construction, type, additions and repairs. Heating and ventilation details

4. Insulation Data

   Questions pertaining to the type, and date of insulation, the locations where installed, effectiveness, workmanship of installer and financial assistance in installation of insulation.

5. User Habits

   Questions designed to identify occupants' use of potential sources of formaldehyde ????

what are some sources.
- dry cleaning
- clothing [illegible]

25 September 81

CLARIFICATION POINTS on TEST PROTOCOLS

1. Replicate NIOSH requirement is 10% of total measurements even outdoor measurements, but they do not all have to be from the same house, i.e. there can be one per house.

2. Interfering Gas. If a Dräger hole hear the baseboard shows Interfering Gas, a test for Ammonia and other Interfering Gases must be taken even if the upper hole gives a Formaldehyde Reading.

3. A maximum of 2 Interfering Gas measurements only must be taken, but only one on each floor or at each end of the building, i.e. if two walls on one floor or at one end of a building have Interfering Gas, but the walls on the other floor or end of the building do not, then only one Interfering Gas is required. Ammonia must be taken in each.

4. Fungal tests will be done in the week of 19 October or the week of 26 October. We will designate houses, 50 UFFI, 50 Control, 25 of each should be with Moisture Content over 20%.

5. Dräger must be taken in cavity where UFFI is or is supposed to be, i.e. if UFFI was installed outside the outer sheathing, you must get through the outer sheathing to take reading.

6. DuPont - 1200 homes to have badges

   600 homes, 2 inside, 2 outside - to be done as early in the programme as possible
   600 homes, 2 inside only

   Total badges required: 3600 plus 432 replicates = 4032 total required.

   Badges being delivered to Safety Supply in Toronto for pick-up by Scanada. 3800 will have been delivered by 16 October 81

MINUTES

PROGRESS MEETING
NATIONAL TESTING PROGRAMME

Present:

Chaired by: D. Youngson
Dr. T. Adley, Technitrol
J. Watson, SNC Group
Dr. R. Caton, Concord
R. Platts, Scanada (Ottawa)

Date: Friday, 25 September 81
2:00 P.M.
UFFI/ICC Boardroom

C.A. -5 OCT 1981

Item	Subject and Discussion	Action
1.	NIOSH Sampling Time	
	After considerable discussion initiated by Dr. T. Adley, if was agreed that a maximum NIOSH test preparation would be 2 hours provided that:	
	a. the laboratories use a 4 or 5 cm. path length for analysis;	Technitrol Concord
	b. the quality of the Sodium Bisulfite used be the highest quality available;	Technitrol Concord
	c. the Sodium Bisulfite solution be chilled before pouring into the impinger.	Technitrol Concord
	d. If the Drager tube reading is greater than 2 ppm, the sampling time be 1 hour, @ 1 litre/minute. If the Drager tube is less than 2 ppm, the sampling time be 2 hours at 1 litre/minute.	Technitrol Concord

Item	Subject and Discussion	Action
2.	**Clarification Points on Test Protocols**	
	The following points were agreed to:	
	a. Replicate NIOSH requirement is 10% of total measurements even outdoor measurements but they do not all have to be from the same house, i.e. there can be one per house.	All
	b. Interfering Gas. If a Drager hole near the baseboard shows Interfering Gas, a test for Ammonia and other Interfering Gases must be taken even if the upper hole gives a Formaldehyde Reading.	
	c. A maximum of 2 Interfering Gas measurements only must be taken, but only one on each floor or at each end of the building, i.e. if two walls on one floor or at one end of a building have Interfering Gas, but the walls on the other floor or other end of the building do not, the only one Interfering Gas is required. Ammonia must be taken in each.	
	d. Fungal tests will be done in the week of 19 October or the week of 26 October. We will designate houses, 50 UFFI, 50 Control, 25 of each should be with Moisture Content over 20%. ICC is to advise the Contractors and the laboratories of the date in which the samples are to be taken.	ICC
	e. Drager must be taken in cavities where UFFI is or is supposed to be, i.e. if UFFI was installed outside the outer sheathing, you must get through the outer sheathing to take a reading.	

GUIDE FOR TEST TEAMS

Discussion with Occupant

1. Team should say they are doing tests in accordance with the schedule attached to, or received with, the occupant's waiver.
2. The team may let the occupant see the results of tests (Dräger, Moisture, etc), but should explain that results will be provided by the UFFI/ICC with an explanation before [illegible] Christmas.

Discussion with Others

1. Team personnel may say who they are, i.e. employee(s) of Technitrol or whomever.
2. Team may say they are carrying out tests as part of the Federal Government's 2400 home test programme to determine effects of UFFI.
3. Team should refer any third party questions on who is being tested or results of the tests to the UFFI/ICC at the following toll free numbers:

	Toll Free	
All areas except below	1-800-567-6870	
British Columbia	112-800-567-6870	
Northwest Territories and Yukon	1-819-994-0155	(call collect)
Ottawa/Hull	994-0155	

DMY
08Oct81
UFFI/ICC

Appendix B
Oct 16/81

PROCEDURE FOR THE ENUMERATION OF THE FUNGAL AIR SPORA

Materials

Petri plates containing 25 ml rose bengal agar* (6 per house & spares)

*ROSE BENGAL AGAR

rose bengal solution (0.66g Rose Bengal dissolved in 100 ml sterile H_2O)	5 ml
malt extract	12 g
agar	20 g
distilled H_2O	1 L

Sterilize at 15 lbs pressure for 15 min.

- Petri plates with rose bengal agar must be stored in darkness at 2-5°C prior to use.

- Replacement plates should be ordered in addition to the total number of plates required to allow a minimum of 20% of the plates to be replaced if contaminated or otherwise unsuitable for use.

Ceramic tiles (6 per sampling team)
Lysol solution or spray (to sterilize ceramic tiles)
Disposable cloths (to dry tiles after sterilization with Lysol)
Parafilm (to seal Petri plates)
Aluminum foil (to package set of 6 plates from each house)
Marking pens (to write on plastic)
Masking tape (to close aluminum foil packages)

Procedure

1. Examine six Petri plates for contamination. Discard any plates which show evidence of fungal growth and replace from the stock of spare Petri plates.

2. Choose six different rooms which adequately represent the variety of living spaces within the home. These may include, for example, kitchens, living rooms, dining rooms, bathrooms, studies, family rooms or laundry rooms. Do not sample areas that are rarely occupied such as crawl spaces, unfurnished attics, cupboards or closets.

3. In each of the six rooms, set one Petri dish at about table-top height in an open area away from walls and other structures impeding air flow and away from sources of heat and convection currents. Record the time and remove the lid from each Petri dish to expose the surface of the nutrient. Place the lid with the open side down on a ceramic tile which has been cleaned with lysol and dried. Restrict all activity in the immediate environment of the open Petri dishes to avoid contamination from clothing, etc. Replace the lid of each Petri plate after exactly 15 minutes of exposure.

.../2

Discard the Petri plate and perform the experiment again with a replacement plate if the timed duration of exposure exceeds 15 1/2 min. or is less than 14 1/2 min. (note - the time that the plate was closed and the 'total' duration of exposure do not have to be recorded on the data sheet as indicated on that form)

4. On the upper surface near the edge of the Petri plate record the date, the house number, and the plate number to indicate the exposure location for that Petri plate. These data should be written directly on the plastic with the appropriate marking pen. Do not apply masking tape to the plate to record information nor to seal the plates. Seal each Petri plate with Parafilm as follows: cut a strip about 5" x 1/2", remove the backing paper from the parafilm, hold one end of the Parafilm strip against the edge of the plate on the crack between the lid and the bottom of the plate, pull on the free end of the Parafilm with the other hand and wrap the Parafilm completely around the circumference of the Petri plate as the Parafilm stretches to seal the lid to the bottom of the plate.

5. Wrap the six plates from each house in one piece of aluminum foil. On this aluminum foil package record the house number and the date on which the plates were exposed.

Shipping

1. Pack exposed Petri plates carefully to avoid damage to the plates or loss of data during shipping.

2. Plates must be shipped prepaid to the analyzing laboratory at the following address:

Biosystematics Research Institute
Wm. Saunders Bldg.
Central Experimental Farm
Ottawa, Ontario
K1A 0C6
Attn. Dr. J. Bissett

3. Ship by a carrier that will assure arrival at the analyzing laboratory within 48 hours of exposure of the plates. Plates must not be exposed to temperatures below 0°C nor above 28°C during storage or shipping.

4. The conditions under which each lot of Petri plates were shipped should be recorded and reported to the analyzing laboratory.

.../3

Fungal Colony Counts and Analysis of Data

Agriculture Canada has assumed the responsibilities of performing the fungal plate count and completing a basic statistical compilation of these data. A brief account of the procedure to be used by Agriculture Canada to enumerate the fungi follows:

1. Examine plates for loss or damage on arrival. Determine and record any irregularities in the length of time and conditions of shipping. As soon as possible place plates to incubate in darkness at 20°C.

2. Count fungal colonies (excluding yeasts) seven days after the plates were exposed using a colony counter. The presence of yeasts, bacteria and actinomycetes will be determined by microscopic observation and these three categories of organisms will not be included in the fungal counts.

3. Revise the counts 14 days after the plates were exposed to include in the count any new colonies of slow growing fungi.

4. Record these final counts on the reporting sheets incorporating appropriate codes for different categories of missing or inaccurate data.

John Bissett
8 October 1981

Appendix A

Oct 16/81

DETECTRONICS INSTRUCTIONS

Detectronics dosimeters are to be used in 500 homes which have DuPont dosimeters:

a. The 4 measurements should be made as follows:

    (1) 2 at badge location

    (2) 2 in Drager tube hole with a reading. If there is no Drager reading, use detectronics in any hole.

b. Do not store detection tubes exposed to light.

c. Keep [illegible] refrigerated, preferably at 0° centigrade, until use.

d. Slight discoloration at the junction of the fiberglass and the detector reagent in the detection tubes does not adversely affect the performance of the detection tubes.

Y/bp
k:[8]
FFI/ICC

Oct 23/81

PRE-TREATMENT OF SIEVE

New sieve is not washed before use.

Place used sieve in container and wash continuously for at least 24 hrs with distilled water. Place in 100°C oven until dry. When dry, place sieve in airtight container until needed.

Carefully weigh 5 g of sieve and place in bottle #1 or #2. Place bottle with sieve in 100°C oven for 20 minutes. Cap bottle immediately upon removal from oven and cool to room temperature.

PROTOCOL FOR SAMPLING WITH SIEVE

Place weighed, dried and capped small bottle in larger storage bottle.

Attach glass tubes to pump as shown in enclosed copy of photograph. Vacuum grease should be used for attaching two tubes with o-ring between. Tube with glass wool should be placed on top with sieve material to prevent sieve material from entering pump.

Place funnel with taped end in tube and pour sieve in.

Sample for 15 minutes at flow rate of 2 ℓ/min. (A stopwatch set at the same time the sampler is turned on in addition to a bell timer set for 14 minutes seems to help avoid extended sampling time).

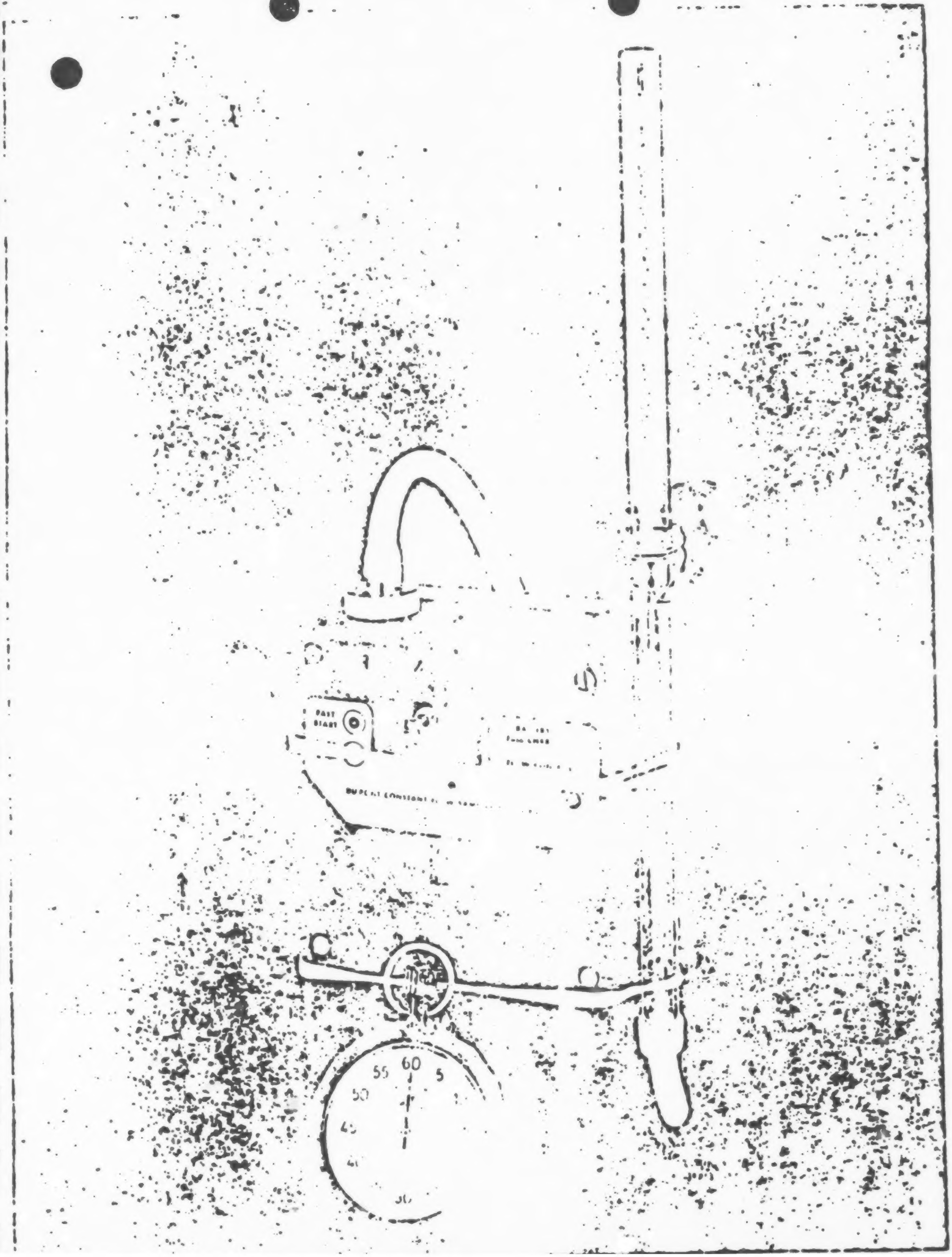
After sampling, return sieve to same bottle it was transported in. (If using plastic capped bottles, seal cap with electrician tape.) Place small bottle in large bottle, cap, and seal large bottle in the same manner as small bottle.

ANALYSIS OF SAMPLES

Soak sieve material in 13.5 mℓ of H_2O for 20 minutes.

Using #2 Whatman filter paper and plastic funnel, filter sieve.

Take 3 mℓ aliquot of solution and treat in same manner as analysis of passive H_2O sample.


FAST START
DU PONT CONSTANT
55
60
5
50
45
40
30

Appendix A

Oct 23/81

PROTOCOL FOR PASSIVE H_2O SAMPLERS

Soak samplers in deionized, doubly distilled water for at least 24 hrs. before each use, changing water at least twice per day.

Rinse samplers thoroughly before and after each use with deionized doubly distilled water.

Just prior to use, shake samplers free of water and drain upside down.

Fill samplers with deionized doubly distilled water and close carefully. Visually inspect membrane to be certain the surface level of the membrane is level.

Transport samplers to sampling site in carrying case. Transport deionized doubly distilled water in teflon jar.

At sampling site, shake water from samplers and drain upside down, making sure outside of membrane is thoroughly dry. Then pipette 5 mℓ of deionized doubly distilled water into sampler and close sampler carefully. Again, visually inspect membrane to be certain it is level.

Place samplers in desired location, carefully noting location and sampler number.

SAMPLER PICK-UP

After sampling period (i.e. 24 hrs) has lapsed,check numbers and locations of sampler. Place samplers in carrying case.

ANALYSIS

Take 3 mℓ aliquot from sampler.

Add 0.3 mℓ of pararosaniline to each aliquot.

Wait 10 minutes.

Add 0.3 mℓ of Na_2SO_3. Wait 30 minutes, then read on spectrophotometer.

DUPONT BADGES

Instructions to Home Occupant(s):

1. Keep the room in which the badge is suspended free of pollutant - creating - activity: cooking, smoking, etc ... for one week.

2. After exposure, at the end of week long sampling: -
   (a) record the end time, date and total exposure time on the identification sticker on the pouch;

   (b) on the provided form record the end time and date. Sign you name under Occupant and keep the green copy;

   (c) insert the badge in the pouch and seal it using the closure provided. Sealing will prevent further exposure;

   (d) place the sealed pouch and the white and yellow copies in the provided envelope;

   (e) tape the envelope or staple it to close it.

M/bap
Oct81
FI/ICC

PROTOCOL FOR ROOM AIR FORMALDEHYDE SAMPLING USING MOLECULAR SIEVE ADSORBENT

The procedure for this test involves pulling room air through 13X molecular sieves at a flow rate of 2 l/min for 15 minutes. Two samples will be taken, one just after the commencement of the NIOSH impinger test and the second to start shortly before the end of the NIOSH test.

Sampling location

Select one sampling location representative of room air for each house. This location should be one of the two locations selected for performing the NIOSH impinger test.

Use a suitable stand to locate the pump 24" to 48" from the floor.

Sampling procedure

The pump (DUPONT P-4000 A) is supplied already calibrated for a sampling rate of 2 l/min.

The pump incorporates a timer which is preset to sample for exactly 15 minutes.

Open the control panel lid on the pump by loosening the two screws on the side of the pump.

A set of 8 control switches (white switches on a red background) is located at the bottom of the panel.

Ensure that the switches are positioned as follows:

Switch No.			
1 - 5	Off	Upper	half depressed
6	Open	Lower	half depressed
7	Auto	Upper	half depressed
8	Norm	Lower	half depressed

Ensure that the ON/OFF switch (black switch to the right of the 8 white switches) is "OFF".

Ensure that the glass tube connected to the pump by silicone tubing is positioned vertically (with the open end upwards upwards) as illustrated in the attached photograph.

Take the second glass tube and ensure that glass wool is in place 1" - 2" from the ball joint and also that the ball joint is greased (lightly) with the HIVAC grease provided.

Connect the glass tubes at the ball joints and secure the joint with the clamp provided.

Remove the inner bottle containing sieve from the outer container.

Place funnel with taped end in glass tube on pump and pour in all of the sieve.

Turn on pump. Use ON/OFF switch. Note: After the switch is turned on there may be a lag of up to 15 seconds before pumping starts.

The pump is preset to sample for exactly 15 minutes.

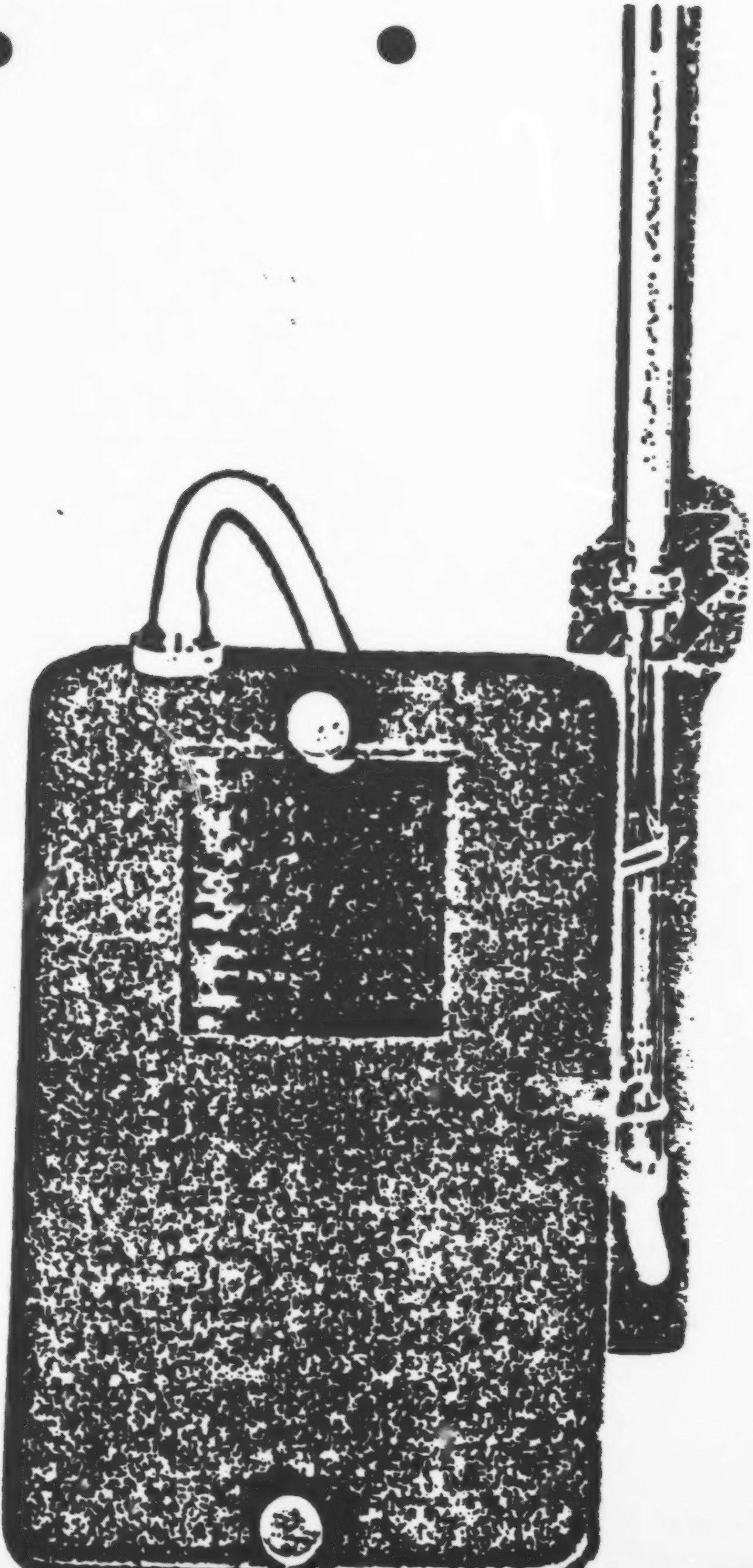
After sampling is completed, immediately remove the upper glass tube, pour all the sieve into the small glass container in which it was shipped, and close the bottle securely.

Inscribe the appropriate house number and sampling location on the label on the glass bottle.

Place the glass bottle in the outer container in which it was transported. Ensure the cap on the outer container is secure and seal cap with tape.

Second sample

The second sample should be taken for a 15 minute period during the last half hour of the NIOSH impinger sampling. Repeat the entire sampling procedure as described above.



QUALITY ASSURANCE/QUALITY CONTROL
SPECIFICATIONS

Department
Of
CONSUMER AND CORPORATE AFFAIRS

September, 1981

TABLE OF CONTENTS

Quality Assurance/Quality Control Specifications September 1981

Amendments to Quality Assurance/Quality Control Specifications:

- Outline of Responsibilities - Quality Assurance/Quality Control September, 1981
- Letter from Concord Scientific Corporation containing technical revisions based on Outline of Responsibilities of the QA/QC Contractor September 18, 1981

A

QUALITY ASSURANCE AND QUALITY CONTROL SPECIFICATIONS FOR A FORMALDEHYDE TESTING PROGRAM

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    0.1.2 Procedures
0.2 Organization
    0.2.1 General

    0.2.3 Duties of QA/QC Contractor

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- .2 Calibration Requirements
- .3 Specifications of Sampling Supplies
- .4 Equipment Reserves
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1.2 Field Sampling

- .1 Pre-Test Information Requirements
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- .3 Data Recording and Transmissal

1.3 Laboratory Analyses

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QUALITY ASSURANCE AND QUALITY CONTROL SPECIFICATIONS FOR A FORMALDEHYDE TESTING PROGRAM

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APPENDIX A

APPENDIX B

APPENDIX C

0.0 INTRODUCTION

This document has been designed to meet the quality control needs of one project - the monitoring of approximately 2300 homes to determine the levels of formaldehyde gas present.

The three basic aspects of any QA/QC procedure, namely, setting procedure, evaluating results, and providing corrective action have been covered in varying detail. Coverage of the first two aspects is more extensive however. Because of the nature of the project (urgent and short duration sampling period) there is limited time for corrective action once the program commences. With few exceptions, any errors will have to be corrected statistically after the sampling and analytical programs are complete. Therefore so that the results obtained across the country are comparative, you are instructed to follow the testing and QA/QC procedures as closely as possible and to report any deviation to the authority responsibility for the QA/QC program.

0.1 Policy and Procedures

0.1.1 Policy

The conclusions drawn from the results of this formaldehyde testing program will be of major significance to both the government and to the home owner who has installed UFFI. Therefore it is imperative that the testing program proceed with a level of quality assurance usually not deemed necessary in many other studies.

0.1.2 Procedures

0.1.2.1 Inform everyone directly involved with the study of its significance. That is, the conclusions drawn from the study will form the basis of government policy planning, and will contribute to the better understanding of health effects relationships.

0.1.2.2 Inform everyone associated with the study of its objective. That is to produce data which are precise, complete, comparable, and representative.

0.1.2.3 Provide training and supervision of all involved.

0.1.2.4 Provide detailed written instructions which cover all aspects of their involvement.

0.1.2.5 Provide a series of internal and external checks to verify the validity of the data produced.

0.1.2.6 Perform a series of on-site inspections to ensure uniformity in the gathering of data and to determine sources of biases.

0.2 Organization

0.2.1 General

The organization of the QC/QA system shall provide each level of reporting with a series of internal checks, to ensure that the results they report are valid. In addition the QA/QC system will have a series of external checks to allow the client to audit the QA/QC contractor and the contractor responsible for the overall supervision of the actual monitoring.

The QA/QC contractor will report directly to the client as will the primary contractor. However as the primary contractor has final responsibility for the quality of all work performed the QA contractor should simultaneously supply reports on quality to the client and the prime contractor.

0.2.3 Duties of QA/QC Contractor

The QA/QC contractor shall be responsible for the following:

1. Organizing and operating the collaborative testing programs.
2. Auditing the activities of all parties involved in the project.
3. Assuring that all groups have received sufficient training.
4. Provide a trained sampling team to perform the inter-field team comparison.
5. The general operation of the QA/QC program as detailed in this QA/QC plan.

1.1 Mobilization

1.1.1 Equipment Performance Specifications

The field sampling teams shall ensure that their sampling equipment is maintained in good operating condition according to the manufacturers instructions, and that it is checked over prior to each field sampling day.

MOISURE DETECTOR: Moisture detectors are factory calibrated and hold their calibration well. However, if the detector is damaged, serviced, or if there is doubt as to its accuracy, the calibration is to be checked against Moisture Content Standards (available for 12% and 22% moisture content).

SAMPLING PUMP, HAND OPERATED: The Dräger bellows-type pump shall be checked daily for leaks, by inserting an unbroken glass tube snugly in the inlet end when the pump is compressed. If the bellows expand in less than two minutes, the pump shall be replaced for wall cavity sampling.

The Gastec pump shall be similarly checked for its integrity.

SAMPLING PUMP, BATTERY OPERATED The pumps shall be calibrated at 1.0 litre per minute with the impinger in line, using a primary standard such as a bubble meter. The pump battery pack is to be fully charged for each day's field use.

SAMPLING PUMP, AC WITH CRITICAL ORIFICE: Each pump and orifice assembly shall be calibrated at 1.0 litre per minute with the impinger in line, using a primary standard such as a bubble meter. The pressure drop across the orifice shall be recorded.

1.1.2 Calibration Requirements

Calibration of sampling pumps shall be conducted both before and after every field day. The daily calibration checks may be done with a secondary standard such as a mass flow meter. A primary standard shall be used for pump calibration on a weekly basis or after not more than 40 hours operation, whichever is less.

1.1.3 Specifications of Sampling Supplies

The sampling supplies used in several of the tests have a relatively short life expectancy and important maintenance requirements.

SODIUM BISULPHITE ABSORBING SOLUTION (1%): The solution shall be dated when made up. It is to be kept cool or refrigerated as much as possible. The solution is to be discarded daily.

DRÄGER/GASTEC/KITTAGAWA COLORIMETRIC TUBES: The colorimetric tubes have a shelf life of one to two years at storage temperatures below 30°C. However, the lower the storage temperature and shorter the storage times, the smaller the changes in their chemical properties.

Therefore, the field team shall ensure that the tubes in use are from a reliable source, are kept cool or refrigerated as much as possible until use, are within their noted shelf life, and have their lot numbers recorded.

FUNGAL SPORE GROWTH MEDIA: Growth media for fungal spore samples shall be dated with production and expiry dates when made up. They are to be kept refrigerated until use, and discarded if their date of expiry is past before use.

1.1.4 Equipment Reserves

Equipment requirements for each home being sampled are outlined in the procedures manual. The numbers of sampling pumps, impingers, and passive monitoring devices to be used in each house will be determined from the basic sampling load outlined in the procedures, manual, plus the replicate and blank sample requirements outlined in Section 1.2.2 of this report.

In case of equipment failure or sampling error, every field team shall carry with them limited equipment reserves. Recommended reserves include:

- 1 extra sampling pump or battery pack
- 1 extra impinger
- 1 extra passive monitor
- extra absorbing solution
- extra colorimetric tubes for formaldehyde, moisture and ammonia
- extra fungal spore sampling swabs and plates
- extra thermometer (unless the thermometer in use is housed in in a psychrometer case which minimizes the risk of breakage)

1.1.5 Data Requirements

Data requirements are outlined on Sample Data Sheets in Section 1.2.4 Data Recording and Transmissal. Additional data requirements from the field teams are:

1. Pump calibration records
2. Dated supplies use records
3. Daily journal of observations made, problems encountered in the field.

1.1.6 Checklist

A checklist of materials, equipment, and information required in the field shall be developed to ensure efficient mobilization. It is recommended that this be prepared by the participants as a final exercise during their training program.

1.2 Field Sampling

1.2.1 Pre-Test Information Requirements

It is important to ensure that the houses being sampled have been prepared according to the procedure outlined in Section 2.1 of the Procedures Manual.

Therefore, a pre-test check shall be made of the preparation procedures used in the house to be sample. The check shall consist of a preliminary inquiry of the homeowner to describe how be prepared his house, followed by several detailed questions relevant to the method as it relates to his house. (e.g. Were the smokers in your family uncomfortable last night? Was your car in the garage last night?)

A checklist of pre-test information requirements has been provided. Individual data sheets detail the data required signature requirement on the data and checklist pages ensure a degree of care in completing the forms. The local Supervisor shall ensure that field sampling teams complete the forms carefully.

1.2.2 Quality Control - Sample Collection Methods

1.2.2.1 Replicate Samples

Replicate sampling is a means of determining variations induced by the sampling method in the field. Replicate sampling is recommended for sampling methods by which few samples are taken in each house and for which a known degree of precision is important. Included in this category are room air samples for formaldehyde (both the NIOSH method, Lawrence Berkely revision, and the passive monitors, Dupont), and for interfering gases (#123 Standard Methods of Air Sampling and Analysis).

Replicate sampling is not recommended for those sample parameters which, by their nature, may be expected to show large inter-sample variations even on a side-by-side sampling basis. Included in this category are fungal spore samples, and wall cavity samples for wood moisture and formaldehyde. The large numbers of samples of these parameters to be taken in each house will establish a range of values for that house. Individual sample precision is not considered to be so critical in these cases.

Replicate sampling is to be done on 10% of the air samples for formaldehyde (NIOSH-revised method) 5% of the air samples for formaldehyde (passive monitors - Dupont method) and 10% of air samples for interfering gases. The total number of specified samples and replicates for 2,300 homes is therefore:

	Samples Specified Per House	Total Specified	Survey Replicates
Formaldehyde in air (NIOSH-revised)	3	6900	690
Formaldehyde in air (passive-Dupont)	2	4600	460

The locations for replicate sampling of formaldehyde in air are to be assigned using a random numbers table and the house identification numbers previously assigned. For example - enter a random numbers table randomly; four place numbers are needed, so four digit columns should be used; if the number is 2300 or less, assign the house with that number a replicate sample; if the number is greater than 2300 or repeats pass on to the next.

The location for replicate sampling of interfering gases are assigned to project teams as a sequential house number in which the sampling is required (5th, for example).

1.2.2.2 Sample Blanks

Requirements for sample blanks are as follows:

PARAMETER	BLANKS RECOMMENDED
Formaldehyde in air (NIOSH revised)	1 per home
Formaldehyde in air (passive Dupont)	2% of samples
Fungal spore swabs	1 per home
Fungal spore plates	1 per home
Interfering gases	1 per home

Assuming the 2300 homes are tested at a rate of two per field team day, the anticipated total numbers of samples, replicates, and blanks are as follows:

PARAMETER	SAMPLES SPECIFIED PER HOUSE	TOTAL SPECIFIED	REPLICATES	BLANKS
Formaldehyde in air (NIOSH revised)	3	6900	690	2530
Formaldehyde in air (passive Dupont)	1	4600	460	92
Interfering gases (Impinger)	--	as needed --		
Ammonia in wall cavity (detector tube)	--	as needed --		
Formaldehyde in wall cavity (Dräger)	10	23000	-	-
Relative humidity in wall cavity (Dräger)	10	23000	-	-
Wood Moisture	≥10	≥ 23000	-	-
Fungal spore swabs	10	500	-	500
Fungal spore plates	6	3000	-	500

1.2.2.3 Sample Identification

Replicate and blank samples will be labelled such that they are indistinguishable from specified field samples. Similarly, no indication of these will be given to the analytical laboratory on the data sheets accompanying the samples to the laboratory. Only the field data sheets which are sent to the local supervisor and project manager will record the sample designations.

1.2.3 Data Recording and Transmissal

Data collected in the field will be recorded upon data sheets similar to those following in this section. The data sheets are designed to contain relevant field information for the project records. They constitute a check to ensure all appropriate monitoring tasks are done, questions are asked, and observations are made. Therefore, all data sheets are to be filled in by the field team, or explanation given for incomplete data. Every data sheet requires the signature of the field team.

The data sheets indicate the route of transmissal for the various kinds of information. A summary checklist of sampling done in each house provides that information for the homeowner, as well as for the local supervisor's identification of houses and the project manager's records of progress. A field data sheet for formaldehyde in wall cavities and room air provides sampling details necessary for calculating and validating results to the local supervisor and project manager. The analytical laboratory receives from the field team only a list of sample numbers on the lab reporting sheet. The lab returns the results on a copy of the same sheet to the local supervisor and project manager. The other sample data sheets included in this section are self explanatory. Together, they constitute a work package for each house.

1.3.1 Quality Control - Lab Analytical Methods

1.3.1.1 Replicate Field Samples

The analysis of replicate field samples (not identified as replicates in the sample designations received by the laboratory) will provide a measure of precision of the field teams sampling method. This measure of precision will be the composite of (a) variation in results arising from random errors in their sampling method; and (b) variation between repeat analyses within a lab.

The component (a) cannot be determined independently because any single determination must contain both sampling and intra-laboratory variation. It can, however, be estimated by assuming (b), the intra-laboratory variation due to random error is small and relatively constant, or by subtracting (b) which has been determined separately.

The component (b) may be expected to be common to all laboratories, the result of random sources of error in the procedure. A measure of its contribution to the overall error will be determined in the interlaboratory testing program outlined in Part III of this report.

A measure of precision involving both components (a) and (b) may be determined by using the differences between analytical results from each laboratory of each sampling team's replicate field samples. These differences may be expected to form a normal distribution about a central axis which represents 0 difference between the two values. The standard deviation of the differences (D) is a measure of variance of the two samples and is calculated by the formula

$$S_r = \sqrt{\frac{\Sigma(Di - \bar{D})^2}{n-1}}$$

Because two measurements are involved, the calculated standard deviation is twice the standard deviation of a single sample.

The measure of precision of single samples from each field team is the standard deviation of the differences divided by $\sqrt{2}$.

Assuming the contribution of component (b), the intra-laboratory variation due to random error, is small and relatively constant, the S_r calculated above may be used to compare precision of the field teams in their sampling methods.

The analytical results of replicate samples will be reported with the sample results to the local supervisor.

1.3.1.2 Duplicate Analyses

A measure of intra-laboratory precision may be determined by sampling splitting and duplicating analyses. However, sample splitting during the analytical procedure allows technician expectation and well-meaning censorship to confound the results. Therefore, duplicate determinations of field samples are not recommended for this project.

Instead, intra-laboratory precision will be determined as a part of the collaborative study described in Part III of this report.

1.3.1.3 Blank Samples

The analysis of blank field samples (not identified as blanks in the sample designations received by the laboratory) will provide a measure of the error induced by sampling materials and sample handling methods.

The Analytical results of blank samples will be reported with the sample results to the local supervisor.

1.3.2 Data Recording and Transmissal

Formats of data reporting and routes of transmissal are indicated by the data sheets in the home data package in Section 1.2.4.

The chemical laboratories shall receive the impinger samples (NIOSH-revised method) identified by only a code and a sampling date. There shall be no differentiation between samples, replicates and blanks.

The laboratories shall also receive the passive dosimeters and field data sheets directly from the homeowners

The formaldehyde results shall be reported on the lab reporting data sheet both in absorbance units and in total micrograms formaldehyde. The standards which were run with the samples shall also be reported in the format of an attached standard curve. The information shall be forwarded simultaneously to the local supervisor and the project manager. The results and calculations, when completed by the local supervisor, shall be copied and sent to the project manager.

A central chemical laboratory shall also receive samples for the analysis of interfering gases, on an occasional and intermittent basis. The results shall be reported on the field data sheet with appropriate backup (chromatogram traces, standard curves). The information shall be forwarded to a record keeping agent designated by the client.

The biological laboratories shall receive fungal spore samples with the field data sheets. The results shall be reported in standard laboratory format, with summaries or cross-reference coding noted on the field data sheets. The results shall be sent to a record-keeping agent designated by the client.

1.3.3 Data Validation

Data validation is planned at several stages and responsibility levels in the project. The first level of data validation is at that of the local supervisor, who has the responsibility for co-ordinating the field teams in his region.

The purposes of the first level of validation are:

1) To rapidly identify and correct weaknesses in the local field program;
2) To report the results of room air formaldehyde concentrations as promptly as possible to the homeowner;
3) To refer questionable results and perceived problems to the project manager for further validation.

The local supervisor receives the complete field sampling data package, which records sampling parameters, locations, replicates/blanks, and results from the field. The local supervisor also receives the report of analytical results from the laboratory. It will be the responsibility of the local supervisor to calculate the time-weighted average air concentrations sheet In addition as outlined in the calculation the following reviews shall be conducted:

1) Field data sheets shall be reviewed promptly for completeness and quality of field reporting. Field teams shall be informed as soon as possible of shortcomings in their recordkeeping.

2) The Lab Reporting Data Sheet shall be reviewed for evidence of correct preparation of standards. Inconsistencies shall be investigated, and the results of the investigation relayed to the project manager.

3) The sample results shall be identified as blanks, replicates, and sample locations.

4) Sample blanks in excess of 0.5 ug formaldehyde shall require an investigation of sample handling methods. The results of the investigation shall be relayed to the project manager.

5) Sample blanks in excess of 0.5 ug formaldehyde and equal to or greater than 50% of the sample results shall require rejection of the sample values. Notification of rejection of sample values shall be given to the project manager..

6) Sample replicates with differences in paired values in excess of 15% shall require an investigation of sampling and/or analytical methods. All samples taken by the project team(s) involved shall be subject to scrutiny. Sample results shall be referred to the project manager for release to the homeowner.

7) Sample replicate values with differences of less than 10% shall be averaged in calculation of the results.

8) Calculated room air concentrations (C_{TWA}) of formaldehyde shall be compared with wall cavity concentrations of formaldehyde (Draeger short term samples - C_{ST}). If $C_{TWA} > \frac{1}{5} C_{ST}$ or $C_{TWA} < \frac{1}{60} C_{ST}$, the sampling data shall be referred to the next level of validation before they are released to the homeowner.

2.1 Sampling Program Designation

The Project Manager shall receive a list of homes containing urea formaldehyde foam in which monitoring is to be conducted.

The Project Manager shall allocate these homes to be sampled to each field sampling team. The allocation shall be based on the geographical location of the houses, the experience of the sampling teams, an assumed sampling load of two houses per field team sampling day, and a field schedule of four weeks duration.

The Project Manager shall also allocate reference homes to be sampled to each field sampling team.

The Project Manager shall designate in which houses the replicate samples are to be taken, as outlined in Section 1.2.2. The Project Manager shall also ensure that the requirements for sample blanks, as outlined in Section 1.2.3, are fulfilled by the field sampling teams.

To ensure that sample designations are clearly communicated to the field sampling teams, the Project Manager or his agent shall make up a work package for each house, from which the field team can work. The work packages for UFFI homes shall contain the following data sheets:

1) House Identification Sheet
2) General Weather Conditions
3) Home Questionnaire

4) Room Air Formaldehyde. Indicate requirement for replicate and/or duplicate samples on sample sheet.
5) Sample Transfer and Lab Reporting Data Sheet
6) Wall Cavity Measurements: Formaldehyde, Ammonia, Water Content and Wood Moisture Content Data
7) Fungal Spore Samples
8) Interfering Gases
9) Passive samples
10) DuPont Passive Dosimeter
11) Sample Location Diagrams

The work packages for reference homes shall contain only those data sheets relevant to the tests conducted there (see Procedures Manual, Section 2.10). Therefore, in work packages for reference houses, wall cavity measurements and interfering gas (aldehydes only) are to be omitted.

The work packages will constitute the work assignment for the field sampling teams.

2.2 Central Document Control and Sample Tracking

The Project Manager, or his designated agent[1], shall maintain copies of all field sampling and lab analytical data sheets

as they are completed. In this way, the progress can be monitored and questionable data brought to a second level of review.

[1] The "designated agent" may appropriately be the QA/QC Supervisor.

2.3 Data Validation

Preliminary data validation was conducted at the level of the local supervisor. Further data validation shall be conducted at the level of the project manager. The purposes of this second level of validation are:

1) To examine overall trends in data quality, and initiate corrective action where appropriate; and
2) To allow further scrutiny of questionable or inconsistent data before reporting room air concentrations of formaldehyde to the homeowner.

The project manager will receive a copy of the sample homes field data sheet packages, as well as chemical laboratory results as they are generated. The project manager will also receive from the local supervisor a copy of results calculations (room air formaldehyde concentrations), and referral to those samples which:

1) Were taken on the day the blank(s) were questionable (formaldehyde blank > 0.5 ug) and were greater than 50% of the sample results;
2) Were taken by a sampling team whose replicate samples differ by more than 10%; and
3) Have room air concentrations of formaldehyde (C_{TWA}) > 1/5 C_{ST} or C_{TWA} < 1/60 C_{ST}

In the case of questionable blanks, the project manager shall attempt to identify the cause and number of samples affected by that cause.

- If the cause is suspected to have contributed a constant bias, the rejection criteria applied by the local supervisor shall stand. A code (B) shall be used to designate the reason for rejection of results.

- If the cause is suspected to have contributed a highly variable error, rejection criteria shall be re-evaluated with the QC supervisor.

- Corrective action shall be taken on the cause.

- If the cause of high blank values cannot be positively identified, all samples of that parameter taken by that field team from the various good blank until the next good blank must be considered as potentially affected. (For room air formaldehyde -- revised NIOSH method, and interfering gases, this would affect approximately ten houses' samples; for room air formaldehyde -- passive dosimter, this would affect 50 samples.) The results of these samples, rejected or corrected for blank values, shall be reported with the code (B), designating the type of error potentially incorporated in the results.

passive

In the case of replicates, the performance of field teams whose field replicates differ by more than 10% shall be compared with that of other sampling teams.

The project manager or the QC supervisor shall estimate the precision of the field sampling methods by calculating the standard deviation(s) of the differences between replicates of each field team. If the S_R values differ significantly, the contribution of intra-laboratory precision (determined in the collaborative testing program) shall be subtracted, to obtain S_R (random error).

- If the S_R values do not differ significantly among teams, the lower precision may be expected to be due to the sampling method. All sampling results by that method are affected and results should be reported together with degree of overall precision.

- If the S_R values do differ significantly among the teams, those with the large S_R values shall have their sampling methods audited. Their frequency of replicate sampling shall be increased to once per day until differences between replicates decrease to <10%.

- Results from sampling teams with large S_R values shall be reported with the code (R), designating the type of error potentially incorporated in the results.

In the third referral circumstance, the inconsistent data ($C_{TWA} > 1/5\ C_{ST}$ or $C_{TWA} < 1/60\ C_{ST}$) shall be scrutinized, to determine whether the data represent an outlyer sample or an error in the results. The project manager shall review the sampling conditions, the house construction information, the results calculations, and the overall results. The project manager and the QC supervisor shall determine whether random error or bias in the sampling and analytical procedures will have contributed significantly to the results.

- If a source of error can be positively identified, the cause shall be corrected. Criteria for rejecting or accepting data shall be established with the QC supervisor, according to the type of error.
- If a source of error cannot be determined, and the results appear after detailed examination to be real, they shall be reported as such.

2.4 Instruction Manuals

Instruction manuals shall be provided to the project participants. To ensure most effective presentation of required information, the following formats are recommended:

1. Detailed procedures manual (see "Procedures Manual for the Sampling of Homes Insulated with Urea Formaldehyde Foam).

2. Summary field and lab manuals.
   The objective of these is to provide an abbreviated manual of method. They might best be prepared by the participants themselves from the more detailed manual; as a final exercise in their training program.

3. Trouble shooting manual (for field sampling teams).
   The objective of this manual is to provide a summary of the most common problems encountered in the field.

2.5 Equipment Procurement

Sampling equipment and supplies shall meet the sampling requirements outlined in the procedures manual. In particular, the following specifications shall be met:

SAMPLING PUMPS, ROOM AIR FORMALDEHYDE TESTS: Sampling pumps for room air formaldehyde tests shall be capable of drawing one litre per minute ± 5%

over a period of continuous operation of eight hours. If AC pumps are used, they should be capable of maintaining a vacuum of at least one-half an atmosphere at a flow rate of one litre per minute across the limiting orifice.

IMPINGERS: Impingers shall be capable of retaining 20 mL absorbing solution without splashover. They shall also be of a material which is not rubber-containing, and which can be cleaned in an acid (nitric:sulphuric) bath.

TRANSFER BOTTLES: For impinger samples which are transferred to the lab in sample bottles, these transfer bottles shall be leakproof, and if a non-rubber containing material which can be cleaned in an acid bath.

COLORIMETRIC TUBES FOR WALL CAVITY SAMPLING: Colorimetric tubes for wall cavity formaldehyde sampling shall have a detection limit of 0.5 ppm and a measurement range of up to 20 ppm. This may be accomplished through the use of more than one concentration range tube.

SAMPLING PUMP, HAND OPERATED: The hand-operated sampling pump shall be of the same manufacturer's name as the colorimetric tubes in use.

WOOD MOISTURE DETECTOR: The wood moisture detector shall be a resistivity-type moisture meter, with a measurement range of 0.5 to 50% moisture content. It shall have been calibrated within the recommended time period stated by the manufacturer.

ANEMOMETER: The portable anemometer shall have an accuracy of ± 10%, and have been calibrated within the recommended time period stated by the manufacturer.

3.1 Quality Planning

Quality planning is conceptualizing the sequence of actions needed to accomplish the task at hand and communicating these to the groups who will execute these actions. Once the objectives of the study are understood it is only a matter of some imagination and effort to devise a quality plan.

The objectives of the study have been provided by the client, Consumer & Corporate Affairs, as detailed in the RFP, and section 0.2.2 of this document.

As a contractor involved in this study you are expected to do your own Quality Planning using as your guides in addition to your own in-house policies, the RFP, the Procedures Manual and this document. This document in itself is a quality plan.

3.2 Training

All personnel involved in any aspect of the project affecting the quality of the data shall have sufficient training in their jobs to contribute to the reporting of high quality data. Recommended training is described in this section.

They shall also be informed of the overall project, its aims and objectives, so that they have an appreciation of the value of their tasks. This should serve as a motivator to have them perform their tasks with care.

3.2.1 Sampling/Analytical Team Combined Training

To help in developing an apppreciation of their (Sampling/Analytical Teams) tasks and to allow the sampling team to converse intelligently with home owners during sampling, the following lecture - Lab/Field type training program should be provided. Phase 1 is intended to provide background on UFFI in the following areas:

3.2.1.2

- → the mixing and injection of the starting materials
- → problems associated with improper ratios.
- → what shrinkage indicates
- → effect of moisture & fungus
- → overview of tests to be performed (both field & lab)
- → health effects
- → not to interpret guidelines
- → TWA, AEL (residential)
- → who & when results available

Copies of two publications, Appendix A and B, shall be provided.

After allowing the teams with enough time to read the publications and to ask questions, a written test should be given to aid in their retention of the information and assure that there is comprehension of the information.

Satisfied with the above the instructor should separate the field and laboratory personnel for more detailed training in their respective areas.

3.2.1.2 Laboratory analysis personnel

The amount of training given laboratory personnel will depend upon their individual backgrounds. For the purposes of this document it is assumed they are trained laboratory technicians or technologists. Therefore after providing them with a copy of the analytical method and a brief discussion with the lab supervisor re: points of error, etc. they should [illegible] analyze the pre test samples provided by the QA/QC contractor. They should be instructed that any deviation from the written procedures can not be tolerated.

They should be instructed in the complete Q.C. protocol, covered elsewhere in this document.

3.2.1.3 Field Sampling Teams

3.2.1.3.1 Lecture Topics - It is assumed that the field sampling teams will have little if no experience in formaldehyde sampling and house construction.

Sampling Points

So that the samples taken will be as representative as possible of the house as a whole, the sampling teams should be made aware of wall and floor construction. A small mockup of a wall and adjacent flooring would be helpful in helping them to visualize their target sampling points.

Instruction should be provided as to how to locate sampling points and why these points should be chosen.

Instructions to recognize and verify UFFI in wall cavities.

Sampling Equipment

A. The sampling teams should be instructed in the maintenance and calibration of the following equipment.

1. sample pumps
2. impingers
3. Dräger tubes & pumps
4. Dupont badges
5. sorbent tubes
6. psychrometer
7. anemometer
8. moisture meter
9. other

B. proper use of this equipment

C. sources of error and warned of ways how these devices are frequently misused.

D. sample handling techniques.

Misc. Instruction

labelling

record keeping

sample storage & transport, frequency of replicate sampling.

Provide the Field sampling teams with copies of NIOSH Field Calibration Methods and Methods for Transporting Samples. Appendix C.

3.2.1.3.2 Hands on Training for Field Personnel -

Although those involved in field sampling have been provided with classroom instruction in the use and operation of the various sampling instruments, and have received a copy of the test procedures manual, it will be necessary to conduct a two stage field training exercise as outlined below.

Stage one shall involve having the instructor take the sampling crews to a test site and have the crews observe the instructor perform the required tests.

Stage two shall require a second test site for each team where the instructor would supervise and instruct the crew while they performed the actual sampling.

Follow up visits by the instructors during the first week of field sampling are recommended.

3.2.1.4 Test for Laboratory personnel

3.2.1.5 Test for field personnel

A sample of the type of test to be given to field personnel is given below. The instruction given should be adequate to allow all persons writing this test to correctly answer all questions.

1. A worker in a plant mixes 300 gallons of formaldehyde solution in an open vat for twenty minutes once a month. Her

exposure would be classed as

a) high level chronic exposure
b) high level acute exposure
c) low level acute exposure
d) low level chronic exposure

2. A homeowner who spends 12 hours a day in his home where the level of formaldehyde is 0.06 ppm would be subject to

a) high level chronic exposure
b) high level acute exposure
c) low level acute exposure
d) low level chronic exposure

3. Persons exposed to very high levels of formaldehyde gas may experience all but the following symptoms

a) eye irritation
b) nose "
c) ear "
d) throat "

4. Which of the following does not produce formaldehyde

a) smoking tobacco
b) smoking marijuana
c) running an automobile engine
d) burning toast
e) boiling water

5. When measuring the moisture content of wood, high moisture levels cause a) more electricity to pass.
b) less

6. Knowing the flow rate of your impinger's pump is

a) unimportant to the test

b) so-so important to the test

c) quite important " " "

d) critical to the test

7. The time it takes for the bellows on a Dräger pump to expand when a tube is properly inserted for testing (i.e. ends removed)

a) ~ 1/10 second

b) ~ 1 second

c) ~ 6 seconds

d) ~ 25 seconds

8. The time it takes for the Dräger pump bellows to expand if it doesn't leak when an unbroken tube is inserted is

a) ~ 2 seconds

b) ~ 10 seconds

c) ~ 20 seconds

d) greater than 1 minute

9. The most common error is using a Dräger tube test for formaldehyde is

a) inserting tube backwards

b) not breaking inner xylene tube

c) working in dim light

d) talking while performing test

10. Make certain you touch the impinger liquid before sampling to assure yourself that it is at room temperature.

a) true

b) false

11. It doesn't matter if you allow the electrodes of the moisture meter to touch water or metal.

a) True

b) False

12. Formaldehyde is present at room conditions as a

a) Gas

b) Liquid

c) Solid

13. The drill bit used to drill the holes for the drager tubes is

a) 1/32

b) 1/4

c) 11/32

d) 21/32

14. The impingers are filled with a solution of water and

a) sodium bicarbonate

b) sodium bisulfite

c) sodium bicurate

15. In the lab analysis is made

a) potentietrically

b) spectrophotometrically

c) pH

16. When Dräger tubes detect formaldehyde one section will turn

a) white

b) blue

c) red

d) pink

17. In a reference/control house, the number of moisture measurements to be made is

a) 1

b) 10

c) 2

d) 0

18. It is proper to test a house at noon if someone smoked at breakfast but opened the window to rid the area of smoke.

a) True

b) False

19. If you notice mold in a carpet do not bother to do the fungal swabs

a) True

b) False

20. Pumps used to draw air through impingers should be set at:

a) 1.00 cc/min

b) 1.00 liters/min

c) 1.00 cu ft/min

21. If the Dräger tubes give a reading of 0.6 ppm the impingers should be run for:

a) 1 hour

b) 2 hours

c) 3 hours

22. Since the Dupont device is passive it doesn't matter if people smoke in that room.

a) True

b) False

3.2.1.6 Provide QA/QC Supervisor with Test Results

The Project Manager shall supply the QA/QC contractor with written notification of the results of the laboratory and field tests.

The local contractor shall assure the QA/QC contractor that he believes his teams are capable of performing the sampling and analytical procedure in a competent fashion.

3.2.2 Training for Others in Program

It is the responsibility of the Primary Contractor, (Project Manager), to assure himself and the QA/QC authority that all individuals involved in the project are informed and competent.

The provision of a formal training program for procedures other than the sampling/analytical procedures will be left to the descretion of the Project Manager.

3.3 Interteam Testing

3.3.0 The purpose of interteam testing is to determine the the degree of precision and accuracy of the data produced by the various participants in the study. It is is not the intent of this procedure to rate or criticize laboratories or field personnel, but rather to point out problem areas or identify trends which could adversely affect the quality of the data.

Collaborative testing (CT) for laboratories is an old but well known concept. Intersampling team testing has been used much less often. However, for your convenience we have provided a brief overview of the type of CT program to be used in this study. The protocol outlined below, although not ideal due to the constraints applied to this study, will be employed.

3.3.1 Interlaboratory Testing

These procedures will provide one facet of the QA/QC control system for the formaldehyde project.

The QA/QC supervisor will be responsible for the logistics and the execution of this collaborative study.

The time constraint imposed by the nature of this project dictates that this collaborative study be abbreviated using fewer than the desired number of samples. The time constraint further dictates the need for quick responses from the participating laboratories.

The aim of this study is to provide the QA/QC authority with interlaboratory checks. It will also provide the QA/QC authority and the individual laboratory supervisors with the necessary data to monitor intra laboratory results.

The interlaboratory testing procedure will be in two parts. Part one will be completed before the actual formaldehyde sample taking occurs. This is planned to lead to the identification and correction of gross errors before the project commences.

Part two will involve the use of samples identified as routine samples, so that a realistic appraisal can be made of the results. This will require the complete professional co-operation of the laboratory supervisors if these samples are to receive an unbiased treatment.

3.3.1.1 Inter-Laboratory Testing Logistics

a) The QA/QC contractor will prepare formaldehyde solutions in three concentration ranges.

b) The QA/QC contractor will send aliquots to the supervisors of the laboratory participating in the project.

c) The laboratory supervisor will split the sample received into various aliquots. The sample splitting should be done in such a way as to allow enough samples for the determination of replicability and repeatability of each technician employed as well as monitoring the reproducibility of the technician.

d) The laboratory supervisor will designate who is to be the primary technician on this project, i.e. the person who will conduct the majority of the analysis. It is the results obtained by this person which will be used primarily in this study. However, all results obtained by all technicians are to be reported. The laboratory supervisor must allow each technician to first carry out sufficient replicate analysis to familiarize himself with the procedure.

e) The QA/QC contractor will review the data, eliminate outlyers, estimate within laboratory and among laboratory variation.

f) The QA/QC contractor will report the results to each of the participating laboratories, the primary contractor and the client.

3.3.1.2 Analysis of Collaborative Test Data

This will be provided in the final document on QA/QC. Techniques employed will be those provided by Youden, in Statistical Techniques for Collaborative Tests A.O.A.C.

3.3.1.3 SCOPE OF ACTUAL COLLABORATIVE TEST

In both stages of the collaborative testing procedure the QA/QC contractor will provide to each of the laboratories, three samples in three concentration ranges for a total of nine samples.

In stage one of the procedure each laboratory will have their primary technician perform duplicate analysis on each of the nine samples on day one of the testing protocol. On day two of the protocol six of the nine samples (designated by QA/QC) will be analyzed once again, not necessarily by the same person.

Along with the sample, the participating laboratories will receive instructions for storing and subdividing the samples, the number of determinations to be made and details on reporting the results.

In stage two of the procedure, the QA/QC authority will from time to timeprovide the laboratory supervisor with the required samples.

3.3.2 Inter-Intra Field Team Testing

3.3.2.1 Introduction

There are at least three aspects which should be covered.

1. Replicate sampling by a team on site.
2. Determination of team to team variation.
3. Determination of region to region variation.

Aspect number one is the easiest to perform both logistically and cost wise. Details have been provided elsewhere in this document.

The number of sampling sites (homes) involved in aspects two and three will probably not exceed 2% (50) of the total. Due to the nature of this particular project, conventional sampling strategies and statistics will not apply.

To provide some means of gauging the compatibility of the results obtained from the various regions across Canada, it is desirable to have teams from the various regions monitor the same home simultaneously. However, the logistics involved in arranging this testing could make this unfeasible. An alternate method would be to have the QA/QC contractor send a team to the various regions to provide comparative values. However, as the overall organization of the entire formaldehyde project has yet to be defined, it is difficult to provide detail as to what tests can, should and are to be performed.

Another desirable comparison would be that of variation within a sampling region. That is to have two teams from the same region monitor the same house simultaneously.

By combining the results of the above two sampling checks and the resultsof the laboratory collaborative study it could be determined if significant differences exist in the reported data.

3.3.2.2 Specifics of Testing

Available in final document on QA/Qc.

3.3.2.3. Logistics of Testing

Available in final document in QA/QC.

3.4 Audit Procedures

3.4.0 General

Auditing will be conducted of all aspects of the project performed by the various levels of the project team (primary contractor, secondary contractor and field/analytical teams).

Auditing will be conducted by the QA/QC contractor of the three levels involved in the study. It is the responsibility of the primary and secondary contractors to audit the practices being performed by those who report to them.

A record of all auditing should be sent to the QA/QC contractor.

3.4.1 Audit Procedure Field Laboratory Teams

All laboratories and technicians involved in the formaldehyde project will be required to participate in a collaborative testing procedure which will indicate both intra and interlaboratory testing. Details of this procedure are covered elsewhere in this document.

The local supervisor in charge of the field/analytical teams will conduct a continuing audit of the activities of these teams. These tests should include on site visits to monitor such items as the flow rate of pumps, areas sampled, written procedures, completeness of data, etc. Regarding the laboratory, he should periodically submit split samples and dummy data for analysis.

3.4.2 Audit Procedures Others

3.5 Data Validation

3.5.0 General

Data validation is the process where data are filtered and reviewed to determine whether or not they are valid, i.e. measure what they report to measure.

3.5.1 Responsibility

For this study all persons handling the data, from individual laboratory supervisor through to the primary contractor, will be responsible for performing some sort of validation procedure in a timely manner.

3.5.2 Data Streams

All data received will be classified in one of these groups:

A. Acceptable

B. Unacceptable (reject)

C. Review

A list of criteria is provided to help you determine in which slot to place data. It is one of the goals of this study that at least 90% acceptable (valid) data be achieved.

3.5.3. Criteria

3.5.3.1 Completeness

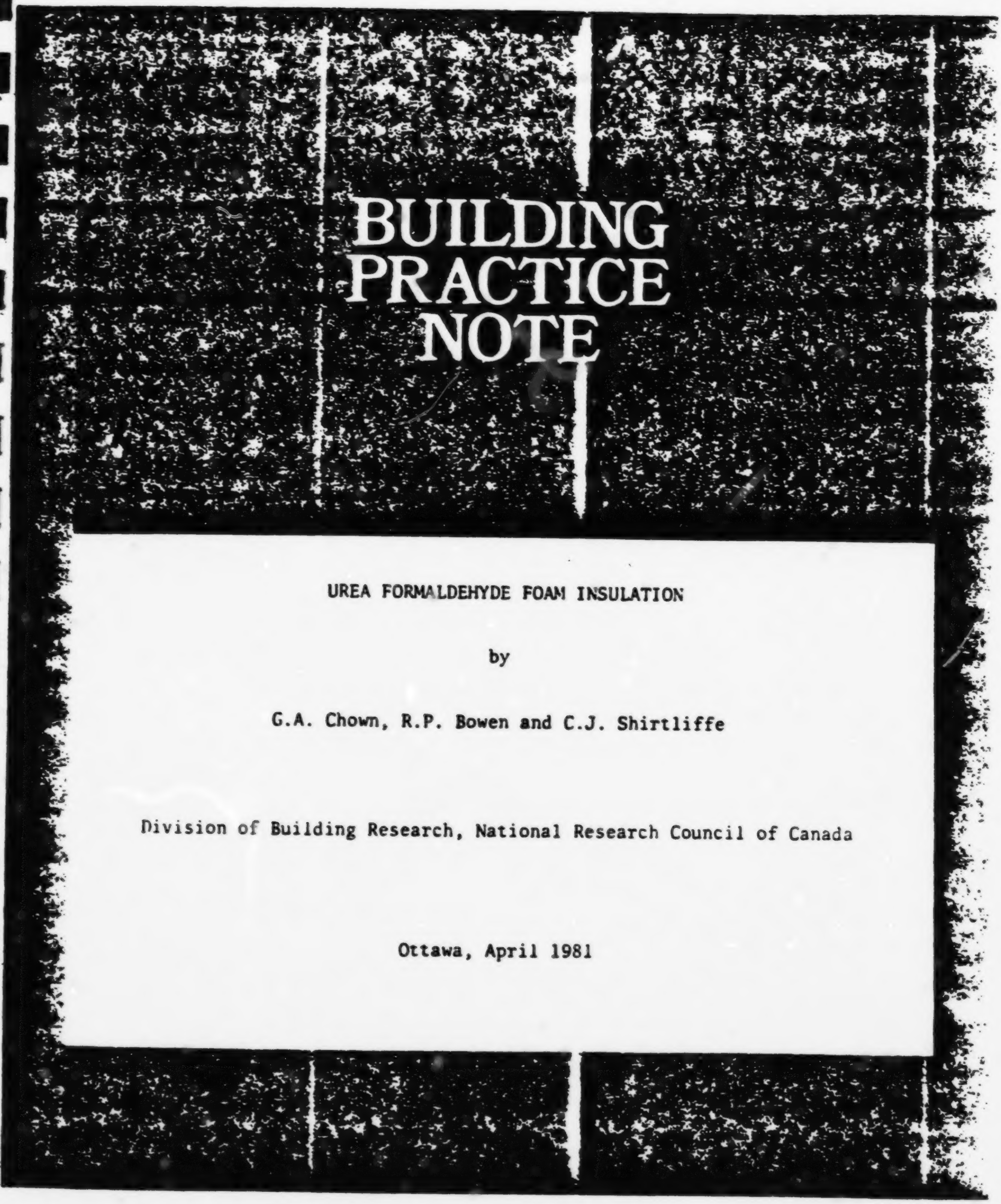
3.5.3.2 Accuracy and precision include values below and at detection limit

3.5.3.3 Extrapolated Values

3.5.3.4 Others

3.6 Reporting

APPENDIX A



BUILDING PRACTICE NOTE

UREA FORMALDEHYDE FOAM INSULATION

by

G.A. Chown, R.P. Bowen and C.J. Shirtliffe

Division of Building Research, National Research Council of Canada

Ottawa, April 1981

National Research Council Canada
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NO. 19

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INTRODUCTION

Urea formaldehyde foam insulation has been used in Canada for a number of years. Its use increased substantially in 1977 when the product standard was issued by the Canadian Government Specifications Board* (CGSB) and the material was accepted by Central Mortgage and Housing Corporation† (CMHC) for limited use under the Canadian Home Insulation Program (CHIP). Consumer demand also contributed to the increased use.

Studies and reports subsequently identified instances of medical problems and structural deterioration of the buildings occurring after the installation of the foam. A ban on the use of urea formaldehyde foam insulation was announced by (National) Health and Welfare Canada and the Department of Consumer and Corporate Affairs on 17 December 1980.

Occupants of homes in which this insulation was installed have become concerned about the effects of the material on their health and on their homes. Experts agree that the likelihood of health problems occurring depends on the duration of exposure to, and concentration of, formaldehyde. In some homes only precautionary steps will be required to reduce the exposure to near normal levels. In other homes a few additional measures, less complicated and much less expensive than removal of the foam, will be necessary. In a small percentage of cases, it will be too difficult to reduce exposure and the foam will have to be removed. Steps taken to reduce exposure will usually eliminate any risk to the building structure.

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* now the Canadian General Standards Board

† now Canada Mortgage and Housing Corporation

Ce document est disponible en français

Every situation is unique and must be considered separately. Occupants of homes insulated with urea formaldehyde foam insulation are encouraged to become familiar with basic information on the characteristics of this material, the factors that affect the severity of a situation, problems that may be encountered, remedial measures that can be taken, consequences of inappropriate actions, and sources of further information and assistance.

The information in this document is presented as answers to questions similar to those asked by occupants. Examples of remedial measures are given.

WHAT IS U.F.F.I.?

Urea formaldehyde foam insulation (U.F.F.I.) is a low density foam made from a plastic resin, a foaming agent and compressed air. These components are pumped from containers to a special gun. The foaming agent and air are combined, coated with the resin and forced through a tube into the wall cavity where it hardens. At the time of installation, U.F.F.I. has the appearance and consistency of shaving cream. It is usually white or cream coloured; one product had blue dye added.

HOW CAN I TELL IF THE INSULATION IN MY HOME IS U.F.F.I.?

The contract provided by the installer may state the type of insulation installed, the trade name, or CMHC acceptance number. Cards containing this information may have been attached by the contractor to the electrical service panel or to a rafter near the attic access hatch. Your local CMHC office or the Ener$ave Advisory Service will be able to assist in identifying the product from either the trade name or CMHC number.

When such information is not given, you may have to identify the foam by recalling the installation procedure or by obtaining a sample for observation. A sample can be obtained by cutting a small hole in a wall at an inconspicuous location such as in a cupboard or closet. Foams may darken with age and if dry will crumble very easily when rubbed between two fingers. The open cell structure can be seen when viewed under a magnifying glass. In a pH test with litmus paper the foam will register acidic.

WHY IS THERE CONCERN OVER THE PRESENCE OF U.F.F.I. IN A STRUCTURE?

U.F.F.I. deteriorates continuously at a moderate to rapid rate so it has a short life compared with other building materials. The rate of deterioration depends on the conditions to which it is exposed. In residential applications, the factors most likely to accelerate degradation are high temperatures and high humidities. Temperatures such as those encountered in a roof space on a summer day cause rapid deterioration. High humidity resulting from the flow of warm humid air from the living spaces into insulated cavities also causes accelerated degradation.

Deterioration of the foam leads to breakage of the cell walls and shrinkage of the insulation decreasing the foam's ability to resist heat and air flow. Formaldehyde gas is released and may be carried into the living space by air infiltration and, at a slower rate, can diffuse through the wall materials. When subjected to elevated levels of formaldehyde for extended periods, occupants can react to the gas and may develop health problems.

Where the cavity containing the foam has not dried properly after installation, fungus may grow on the foam or on other materials in the cavity. Fungus spores can be carried into the living space by air infiltration. Some types of spores are known to cause allergic reactions and sensitization in humans. Fungal growth may also cause deterioration of organic materials in the wall.

WHAT MEDICAL SYMPTOMS MIGHT BE RELATED TO THE PRESENCE OF U.F.F.I.?

Exposure to formaldehyde can cause eye, nose and throat irritation, coughing and asthma-like symptoms, headaches, dizziness, nausea, vomiting and nose bleeds. The severity of the reaction depends on the formaldehyde concentration, the duration of exposure and the sensitivity of the individual. Although there may be no reaction to a single exposure, repeated or long-term exposure may increase an individual's sensitivity to the gas. When sensitized, a person may suffer serious reactions at very low concentrations. Asthmatics may suffer more severe attacks as a result of continued or repeated exposure. High levels of formaldehyde have been found to cause nasal cancer in laboratory animals indicating that humans should minimize their exposure to the gas. Skin contact with U.F.F.I. may cause skin irritation and sensitization to formaldehyde and other substances.

The symptoms caused by repeated exposure to certain types of fungus spores can be similar to those caused by exposure to formaldehyde; the most common are asthmatic in nature: intermittent breathing difficulties, wheezing, coughing, and a sense of constriction.

Persons suffering from these symptoms should consult a medical doctor to verify the cause.

CAN THE PRESENCE OF FORMALDEHYDE AND FUNGUS SPORES BE DETECTED BY ODOURS?

Formaldehyde has a pungent odour at high concentrations but a less definite odour at low concentrations. Most people can detect the presence of the gas at concentrations of 1.0 parts per million (ppm); few can detect it at levels below 0.05 ppm.

Some foams contain agents which mask the formaldehyde odour but do not remove the gas from the air. Others contain chemical scavengers which react with the formaldehyde and reduce the emission of the gas. As the insulation deteriorates, the effectiveness of the scavengers can decrease. The emission of formaldehyde will increase and the odour may become detectable.

Fungus growth on the foam or on surfaces of the wall cavities may emit a musty odour which is not easily identifiable among other household odours. The ability to detect odour from fungal spores varies from person to person.

ARE THERE VISIBLE SIGNS WHEN PROBLEMS EXIST?

The U.F.F.I. in a freshly foamed stud space contains about 2.3 to 4.5 litres (0.5 to 1.0 gallons) of water. Where the wall construction hinders drying, high humidities may be maintained for extended periods. The moisture may accelerate the deterioration of the foam and damage adjacent materials. Blistering and peeling of paint, fungal blooming on the paint, or discoloration of finishes and corrosion of electrical boxes and wiring can occur. Moisture from other sources, such as roof or plumbing leaks, entering a wall cavity containing dry foam can cause similar problems. Improperly formulated or installed foam may release resin-laden water which may seep from the wall cavities. This can cause staining or etching of the wall and floor surfaces below.

Improper installation may also have forced the U.F.F.I. through cracks into electrical boxes, ceiling spaces, or the living space before it sets. In most cases, foam should be removed from these locations. Excessive pressures during installation may have cracked or bulged the interior and exterior sheathing or cladding necessitating removal for cosmetic reasons.

ARE THERE TESTS TO DETERMINE THE EXISTENCE OF OR POTENTIAL FOR A PROBLEM?

Measurements of formaldehyde concentration in wall cavities and living spaces and the moisture content of the wall cavities are useful for analyzing the seriousness of the situation, provided they are done after conditions have been controlled in the house for some time.

The formaldehyde concentrations in a series of stud spaces are a measure of the potential for formaldehyde to enter the living space and an indication of the quality of the foam. These tests can be made with apparatus that is relatively easy to use.

Formaldehyde concentrations in the living spaces indicate the amount of formaldehyde entering these spaces relative to the amount of fresh air entering the house. The measurement can be affected by other sources of formaldehyde in the house such as particle board, cigarette smoke, various household chemicals and by the age of the foam. As this test does not measure concentrations at the source of the formaldehyde, it does not define as accurately the potential for or severity of a problem. It should therefore be done in conjunction with the cavity concentration measurements and under conditions that minimize air changes and maximize formaldehyde emissions and infiltration of the gas. This measurement can also be made after a series of remedial steps have been taken. A comparison of the results with the earlier readings will indicate the effectiveness of the remedial measures. Consultants or commercial laboratories should be hired to perform these measurements since the tests include specialized sampling techniques and laboratory analysis.

Samples of foam and other materials from the wall cavity may be submitted to a laboratory to determine the rate of formaldehyde emission whenever high formaldehyde concentrations in the cavity have been measured. The measurement of the emission rate will help determine which materials should be removed and which should be treated to reduce emissions.

Measurements of moisture content of the wood in the cavities are useful in determining whether fungal growth is affecting the structure or the foam and if the deterioration of, and formaldehyde emission from, the foam could be reduced by drying the cavities. These measurements can be made with equipment that is easy to operate and should be made at the same time as the gas concentration measurements.

Material samples should be submitted to a laboratory for fungus identification whenever a high moisture content has been found. The results will indicate what steps must be taken to prevent decay of the structure.

DOES THE LOCATION OF THE FOAM AFFECT ITS POTENTIAL TO CAUSE PROBLEMS?

When U.F.F.I. is exposed to high temperatures and high humidities or when it is not purged by an exchange of air with the outside, the possibility for formaldehyde flow to the interior of the house is increased. Cathedral ceilings, attics, eave spaces, other roof spaces, floor/ceiling spaces, and masonry, basement and party walls are locations where such conditions can occur. When the foam is installed in these locations, remedial measures may have to be more extensive and the likelihood that the foam will have to be removed is greater.

WHAT STEPS SHOULD BE TAKEN TO REDUCE THE PROBABILITY OF FUTURE DIFFICULTIES IN HOMES WITH NO APPARENT PROBLEMS?

Certain preventive steps should be taken where there are no immediate problems or where remedial action must be delayed.

Openings that connect cavities to living spaces should be sealed. These include joints between window and door frames and the rough wall openings and joints between the wall and floor finishes behind the baseboards. Special gaskets that are approved by the electric utility should be used to seal openings at electrical outlets and light switches.

Both the ventilation rate and interior air pressure should be increased. In houses with forced air heating, a duct with an automatic one-way damper can be connected between the cold air return duct of the furnace and a vent located on the side of the house facing the prevailing wind. The fresh air drawn into the house will decrease the pressure difference across the wall which causes the air infiltration. In houses heated by electric baseboard heaters or hot water systems a forced ventilation system with an air-to-air heat exchanger can be installed; this will reduce both formaldehyde and humidity levels by increasing the supply of fresh air to the house.

WHAT STEPS CAN BE TAKEN TO REMEDY EMISSION AND MOISTURE PROBLEMS?

A number of remedial measures can be followed where there are problems related to the presence of U.F.F.I. The measures selected will depend on the type and severity of the problem. Some will be simple and inexpensive while others can be more complex and costly. The most complicated and expensive is the removal of the foam which would generally involve removal of the interior wall sheathing, disposal of the insulation, cleaning, treatment and testing of the cavity, installation of batt insulation, a continuous air barrier and vapour barrier, and drywall, and thorough cleaning of the house. The decision to remove the foam depends on the formaldehyde concentrations in the cavities, the flow of gas into the living spaces, and the sensitivity of the occupants.

The following examples of hypothetical situations are provided to illustrate the uniqueness of every case.

Example 1

Mr. X and his family noticed an unusual odour in their house after the installation of U.F.F.I., and afterwards occasionally perceived faint odours during damp weather, but had not developed any symptoms of formaldehyde exposure.

i) Mr. X purchased an air sampling pump and tubes for just over $100 and measured the formaldehyde concentration in a number of stud spaces insulated with U.F.F.I.

All the readings were about 1 ppm (parts per million) indicating that: 1) the level was not unusually high, 2) the foam in the cavities tested was of fairly uniform quality, and 3) the odour was most likely formaldehyde carried into the house by leakage of air through the cavity.

ii) He measured the moisture content of the wood in the same cavities.

The readings all indicated a moisture content below 10%. This indicated that the odours were likely not caused by the growth of wood rot fungus and the average relative humidity in the cavity had been low for some time.

iii) Mr. X sealed all cracks and openings between the cavities and living spaces.

The infiltration of formaldehyde-laden air was reduced considerably.

iv) He also installed a fresh air duct system.

The supply of fresh air to the house was increased and the flow of air from the wall cavities into the living spaces was decreased. The damper regulated incoming air and prevented air being drawn out of the duct during adverse wind conditions. Following these steps the odours were not detectable even following periods of damp weather, so no further action was taken.

Example 2

Mrs. Y's family experienced medical problems four months after the installation of U.F.F.I.

i) Mrs. Y and her family visited their family doctor.

The doctor confirmed that the problems were most likely related to exposure to formaldehyde gas and not due to some other ailment.

ii) *Mrs. Y hired a consultant to measure the formaldehyde gas concentrations in the air in the living spaces. The consultant specified how the house was to be operated for the 24 hours preceding the test.*

The readings averaged 0.3 ppm. The measurement was made to confirm that formaldehyde was present at a level significantly higher than the outdoor level and to compare with later readings so that the effectiveness of the remedial measures could be determined.

iii) *The consultant also measured the formaldehyde concentrations in a number of insulated stud spaces.*

The readings were all about 5 ppm, indicating that the formaldehyde level was high. With normal leakage patterns in the house, the level was compatible with the 0.3 ppm reading for the interior.

iv) *The consultant measured the moisture content of the wood at the bottom of the cavities.*

The moisture contents were above 20%, indicating that deterioration of the foam was probably being accelerated by high humidity and that for some time conditions had probably been suitable for fungal growth.

v) *The consultant cut a test opening at the bottom of a stud space in a closet, removed material, filled the space with glass fibre batt insulation, covered the hole with a piece of polyethelene taped around the edges, and sent the materials to a laboratory to be tested for fungus.*

The glass fibre was inserted to reduce heat loss. The plastic sheet was installed to prevent air flow from carrying gases into the house. Tests showed there was no fungal growth so treatment of the wood for fungus was unnecessary.

vi) *Immediately after closing the test opening, a check was made for the source of the moisture in the walls.*

The source was identified as being the moisture in the foam. No other sources such as roof leaks or faulty plumbing could be found.

vii) *Humidity in the house was reduced as much as possible. Holes were drilled through the siding just below the top plate to vent the cavities. Checks were made every few days on the moisture content of the wood.*

The moisture contents dropped to about 12% after 10 days. The moisture content of the foam, the emission of formaldehyde and the odours in the house decreased.

viii) The vent holes through the sheathing and siding were sealed. The formaldehyde concentration in the stud spaces was rechecked three days later.

The three-day period allowed the concentrations to stabilize. The measurements were all just under 2 ppm showing that the drying had been effective.

ix) Mrs. Y sealed all the cracks connecting the wall cavities to the living space.

Infiltration was reduced considerably and with it the formaldehyde level in the house.

x) She had the furnace serviceman install a fresh air duct system.

The formaldehyde level in the house became less noticeable as the fresh air diluted the formaldehyde and the flow of contaminated air from the wall cavities into the living spaces was decreased.

xi) Mrs. Y washed the ceilings, walls and floors, laundered or dry-cleaned the linens and curtains, vacuumed the rugs and shampooed the upholstery.

Most of the formaldehyde clinging to the room surfaces and adsorbed by fabrics in the living spaces was removed.

xii) A second measurement of formaldehyde concentration in the living spaces was made by the consultant.

The concentration had dropped to 0.05 ppm which was close to the expected outdoor level. The symptoms of formaldehyde exposure disappeared over a few weeks. Further steps such as the installation of an air-to-air heat exchanger and chemical absorption filter were deemed unecessary at that time.

* * * *

The Division plans to publish more detailed information on the characteristics and use of U.F.F.I. and on the identification and remedy of problems. If you wish to receive this information, please complete the attached form and send it to:

Publications Section
Division of Building Research
National Research Council of Canada
Ottawa, Ontario
K1A 0R6

For more general information on insulation and energy efficiency, contact:

EnerSave Advisory Service
Energy Mines and Resources Canada
P.O. Box 4510
Station "E"
Ottawa, Ontario
K1S 5K3

Ottawa-Hull	995-1801
Yukon and NWT	1-613-995-1801 (collect)
B.C.	112-800-267-9563 (toll free)
Other locations	1-800-267-9563 (toll free)

Medical doctors requiring further information on the symptoms and treatment of reactions to formaldehyde should contact:

Environmental and Occupational Safety Division
Health and Welfare Canada
Environmental Health Centre
Tunney's Pasture
Ottawa, Ontario
K1A 0L2

1-613-996-4266

Acknowledgement

This document was prepared with assistance from Health and Welfare Canada.

NATIONAL RESEARCH COUNCIL OF CANADA
DIVISION OF BUILDING RESEARCH

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APPENDIX B

B-1

Health Aspects Related to Building Materials[1]

by

P. W. Purdom and Lester Levin[2]

(EXCERPTS)

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[1] Prepared for presentation in the session on "Engineering and Health Sciences with Respect to Energy Conservation," annual meeting American Association for the Advancement of Science, Toronto, Canada, January 6, 1981.

[2] From Drexel University, Philadelphia, PA. Purdom is Director of Institute for Environmental Studies and Levin is Professor of Industrial Hygiene.

Urea-Formaldehyde Foam Insulation (UFFI)

Formaldehyde was first manufactured commercially in 1889.[15] Formaldehyde is used in thousands of industrial and consumer products. It is widely used in textile, funiture, automotive, machinery, energy, construction, and consumer industries. Its reactivity leads to its use in chemical bonding agents (polymers). Ninety-five percent of hardwood panels use formaldehyde resin adhesives.

Urea formaldehyde foams were developed in Europe in 1933.[16] They have been used in northern Europe as an insulating material since the early 1960s. Most installations in the United States were made after the 1976 energy shortage.

Urea formaldehyde foam insulation (UFFI) is made by an installer in the field at the time and at the place of use. It is made from (1) urea formaldehyde resin, (2) a surfactant (called a foaming agent or catalyst), and (3) air. An air compressor and a mixing foaming gun form a resin coated foam that surrounds microscopic air sacs. These harden (cure) in a few days or weeks.

UFFI appeared, at first, to be especially well suited for filling cavities in exterior walls of old uninsulated homes. However, consumer complaints began immediately and have persisted throughout the United States. Some occupants of treated homes claimed that they were made ill and had to move out of their homes.

Subsequent investigations have shown several factors can contribute to problems with UFFI.[17] These include:

1. Excessive amount of formaldehyde in the resin,
2. Excessive amount of catalyst in the foaming agent,
3. Improper ratio of resin to foaming agent,
4. Excessive amount of foaming agent,
5. Foaming at high humidities,
6. Foaming with cold chemicals,
7. Dry density of the foam exceeding manufacturer's specifications.

Problems result because the formaldehyde based insulation and adhesive resins contain free formaldehyde that in the short term escapes as a gas. On a longer term, heat and moisture cause hydrolysis and decomposition that, also, result in the release of formaldehyde gas. The poured in place foam may deteriorate above 80°F and will not properly harden below 53°F.

In preparing for this paper, we queried state and federal agencies. There was no response from many states and some of those responding stated that they had no activities regarding construction materials and interior air quality in homes. Some of the information received has been summarized as follows.

Idaho reported that there have been problems during normal occupancy associated with UFFI, as well as particle board, plywood, and wood paneling.[18] Tennessee reported there had been several complaints regarding both UFFI and new paneling.[19] Indiana reported some surveys that found measurements indoors of 0.02 to over 1.0 ppm of formaldehyde. Occupants reported symptoms varying from eye irritation to breathing difficulties.[20] Kentucky reported 310 complaints in 14 months.[21] Ten percent were from use of UFFI in conventional homes and 90 percent were from mobile and modular homes where particle board and paneling were used. The highest level of formaldehyde gas found was 1.77 ppm. Montana made a survey in 1979 and 1980. There were 54 investigations including 20 residences, 9 mobile homes, and 2 modular homes. Formaldehyde gas found indoors ranged from 0.023 to 0.86 ppm in mobile and modular homes and from 0.00 to 0.62 in residences. An ambient level of 0.032 ppm was found. The UFFI residences were foamed between 1976 and 1979. Other states will be mentioned momentarily when actions taken are discussed.

Several studies have been made concerning the effects of exposure to small concentrations of formaldehyde gas. Suta[22] and Garry[23] both state that a person can smell formaldehyde gas at 0.05 ppm. Swelling of mucous membranes occurs between 0.05 and 0.1 ppm.[22] Irritant effects occur at 0.2 ppm.[23] This may be burning of eyes, weeping, and irritation of upper respiratory passages. Over a few ppm there is coughing, constriction of the chest, and a sense of pressure in the head.[22] There may also be diarrhea and nausea, and skin irritation.[23] There is sensitization to formaldehyde exposure and there may be hypersensitive persons in the population.

The U.S. Consumer Product Safety Commission reported that since 1978, 28 persons have been hospitalized and 68 vacated old homes or could not move into new homes because of formaldehyde gas.[24] This Commission in 1979 requested the National Academy of Sciences to determine if there was a tolerable level of exposure to formaldehyde gas.[25, 26] The Academy reported that formaldehyde gas is mutagenic using non-mammalian test systems--microorganisms and insects--but was negative for the Ames test. The Academy report concludes that there is no population threshold for irritant effects of formaldehyde in humans, but research is needed to fully assess the health effects. It was recommended that formaldehyde be kept at the lowest practical concentration in indoor residential air.

The Academy's report may be superseded by a report of the Chemical Industry Institute of Toxicology. Twelve to 18 nasal carcinomas were found in 36 rats exposed to 15 ppm, 6 hours per day, 5 days per week for 18 months with histologic changes at 6 and 2 ppm. However, four epidemiology studies found no overall excess cancer in persons exposed compared with the general population. The latest information available to us was that the CIIT study was being further evaluated.

In view of these very serious health effects attributed to poured in place UFFI, what actions have been taken by official agencies? The U.S. Department of Housing and Urban Development indicates that UFFI is suitable for HUD housing programs.[27] Its standards require 12.7 mm (1/2 inch) gypsum wallboard interior face. UFFI is to be used only in wall cavities and between floors. It is not approved for use in attics and ceilings. Also, it should be kept clear of heat sources. The spaces where used should be vented to the outside. The HUD bulletin also points out that there is shrinkage during curing. It specifies shrinkage should be no more than 4 percent in any direction. Data from field observations show shrinkage between one and 11 percent after installation, with an average of 6 percent. If there is 6 percent shrinkage, the thermal resistance would be 72 percent of a full thick specimen.

Initially the U.S. Consumer Products Safety Commission issued several "Alerts" about the problem of formaldehyde gas associated with UFFI.[28] That agency has proposed that manufacturers of UFFI be required to provide prospective purchasers with performance and technical data.[29] The Commission recommends as remedies where problems occur increased ventilation by opening doors and windows. It seems to us that if doors and windows have to be kept open, the energy conservation purposes of insulating have been defeated.

Other suggestions include using activated charcoal in furnace and air conditioning filters, and evaporation of household ammonia in closed and ovulated rooms to neutralize the formaldehyde, followed by ventilation. Ammonia could also be injected directly into the insulation. Another suggestion was to apply vinyl wallpaper or low permeability paint to walls. Of course, one can remove all or a portion of the insulation from the wall, which would require ripping off the wall covering. Most recently, based on new toxicological evidence from industry to be presented, the Commission will subsequently meet in early 1981 to vote on a possible ban of UFFI.[30]

Reactions of state and local agencies has varied. The Rocky Mountain Poison Center in Denver has issued a "Position Paper.[31] On the same date, December 4, 1978, the Colorado Attorney General issued a "Public Warning" concerning urea formaldehyde foam.

The Hartford Courant called the public's attention to UFFI problems in November 1977. Subsequently, The Connecticut Department of Health Services investigated 282 cases. It was found that 52 to 66 percent who reported symptoms were exposed to less than 0.5 ppm formaldehyde and odor was detectable at 0.6 ppm.[32] The Attorney General of Connecticut has worked out an agreement with industry (nine companies).[33] Companies are required to use a notice regarding adverse effects and sensitization. There are also suggestions for a procedure to obtain remedy of a problem. In practice, persons have to prove that they required medical attention in order to secure intervention by the Attorney General's Office.

Since February 1, 1979, the Minnesota Department of Health has investigated 575 complaints about formaldehyde problems in homes.[34] The 1980 legislature passed a bill regarding formaldehyde gas in homes. The Health Department was authorized to set a maximum concentration of formaldehyde gas at the time of sale for homes completed after December 15, 1980. A temporary emergency rule was adopted setting the limit at 0.50 ppm. However, an injunction was obtained December 5, 1980, which delayed enforcement.[35] A prepurchase notification required by the bill was not affected and will be effective January 1, 1981. In the meantime, the Minnesota Department of Health is pursuing development of a permanent rule which is scheduled for a public hearing in March 1981.

Legislation was considered in 1980 to regulate UFFI in California.[36] This bill would have limited emissions of formaldehyde to not more than 2 mg per hour per kilogram of insulation at 45°C and 90 percent relative humidity. The bill also set a limit for formaldehyde concentration in inhabited portions of residential or commercial structures of 0.2 ppm. It also required training and certification of installers and a $100,000 bond to cover any remedial action required. Even with these provisions, UFFI could be prohibited if determined to be carcinogenic, mutagenic, and teratogenic. This bill did not pass because of budgetary considerations. The agency delegated responsibility did not have the resources to implement.[37]

Massachusetts has taken the most direct action of any state. Public Health Commissioner Alfred L. Frechette issued a complete ban on the use of UFFI effective November 14, 1979.[38] After public hearings he concluded that the problems were not "...due solely to faulty installation..." and that problems did not seem to be "...associated with only one manufacturer, but rather with the product itself." Massachusetts' tests of 73 homes on request showed 26 percent less than 0.1 ppm aldehydes, 50 percent 0.1 to 1.0 ppm, and 22 percent 1.0 to 2.9 ppm. These values compare with an OSHA value of 3 ppm, [illegible] and NIOSH recommended ceiling limit of 1 ppm for 30 minutes. The action in Massachusetts did not consider the CIIT study.

While there seems to be action regarding UFFI, we received no information concerning action aimed specifically at urea formaldehyde adhesives used in particle board and paneling. Sixty percent of the urea formaldehyde resin produced in 1973 was for particle board and medium desnsity fiber board.[39] It is less costly than phenol formaldehyde resin; however, the latter does not have as much problem with deterioration and offgassing. Phenol formaldehyde resins are used in exterior plywood.

OUTLINE OF THE RESPONSIBILITIES
OF THE
QUALITY ASSURANCE/QUALITY CONTROL
CONTRACTOR

TRAINING

The Quality Assurance/Quality Control, (QA/QC) contractor is responsible for assuring that all personnel involved in any aspect of the testing and QA/QC projects affecting the quality of the data have received sufficient training in their job to contribute to the reporting of high quality data. Personnel without adequate training must undergo a theoretical and practical training program. To assure a uniform and thorough understanding of the jobs to be performed, all personnel involved (requiring training or not), must be able to answer correctly all questions in a given written test.

Following the theoretical training, the field teams personnel are to undergo "Hands on Training" program supervised by the instructors.

The Analytical laboratory personnel are to be instructed in Revised NIOSH and other analytical methods when required (aldehydes impinger and passive dosimeter analyses). The QA/QC contractor is responsible for providing an inter-intra laboratory testing program to assure that the laboratory personnel have sufficient training to perform high quality analyses.

QA/QC contractor is responsible for assuring that all personnel involved in calculating the time-weighted average air and concentration of formaldehyde in p.p.m. and other concentrations from field and analytical data are competent and are capable of passing a written test prepared by the QA/QC contractor.

All personnel involved in field/analytical sampling must be instructed to follow strictly the test procedures as detailed in the Test Protocols.

During training, the personnel shall prepare for their use, under the supervision of the instructors, an abbreviated manual of all methods, calculations, instructions etc...most pertinent to their duties.

The field teams will be supplied with a "Trouble Shooting Manual" prepared by the QA/QC contractor. The manual summarizes the most common problems encountered in the field.

COLLABORATIVE TESTING: Inter-Intra Laboratory Testing

The QA/QC Contractor is responsible for sending to all analytical laboratories involved samples of formaldehyde solution in three concentrations for duplicate analyses. The results from all analytical personnel in all the laboratories will determine the degree of the inter-intra laboratory precision.

The QA/QC samples are to be sent to each laboratory at least twice before the starting of the testing program. This early testing is designed to help in the identification and correction of any gross errors before the project commences. Once the project is underway, QA/QC samples for duplicate analyses are to be sent once a week to each laboratory.

VALIDATION OF DATA

The QA/QC contractor is responsible for validating the results of the replicate sampling and assuring that the replicates differ by less than 10%.

The QA/QC contractor is responsible for validating the results of NIOSH blanks and assuring that they are less than 0.5 mg and not greater than 50% of the sample results.

Values outside the above-mentioned limits shall be scrutinized by the QA/QC contractor and the project manager to determine the cause of the error and recommend a corrective action to be taken (See QA/QC Specifications).

The QA/QC contactor is responsible for validating the results of the room air concentration for formaldehyde and assuring that the concentration is not more than 1/5 and not less than 1/60 of the wall cavity formaldehyde (Dräger) concentration. Values outside the above range shall be scrutinized by the QA/QA contractor and the project manager to determine whether the data represents an outlyer sample or an error in the results. If a source of error can be positively identified, the cause shall be corrected. If the source of error cannot be determined and the results appear after detailed examination to be real, they shall be reported as such.

AUDITING OF THE FIELD TEAM SAMPLING METHODS

The QA/QC contractor is responsible for assuring that the replicate difference does not vary significantly from team to team. In case the difference is significant, those teams with large differences (see pages 39 and 40 of the QA/QC Specifications) shall have their sampling methods audited by the QA/QC contractor and the project manager. The teams frequency of replicate sampling shall be increased to once per day until the difference between replicates decreases to less than 10%. Results from these sampling teams shall be reported with the Code (R), designating the type of error potentially incorporated in the results.

The QA/QC contractor and the project manager are responsible for recommending a corrective action as soon as the source of the problem is identified.

ON-SITE INSPECTIONS

The QA/QC Contractor is responsible for sending a trained sampling team to perform on-site inspections at least four times per testing field team on random dates to check the following: -

1) equipment performance, calibration and proper use of the equipment
2) specification of sampling supplies
3) data gathering and recording
4) the steps in NIOSH sample preparation
5) handling techniques of collected samples, shipping and storage conditions
6) expiry date on dated supplies
7) performance of other tests
8) location of sampling points
9) reserves of equipment
10) sample labelling
11) pre-test check of the house preparation

QA/QC Contractor will report the results of the check to the project manager and the UFFI/ICC.

ON-SITE INSPECTION: Replicate Sampling by QA/QC Team

The QA/QC Contractor is responsible for sending a trained sampling team at least twice, on randomly chosen dates, to run replicate sampling parallel with NIOSH indoor sampling performed by each field team. The data of the replicate sampling analyses will be reviewed separately from regular replicates sampling and the results reported to UFFI and the Project Manager.

INTERNAL QUALITY CONTROL COMPLIANCE

The QA/QC contractor is responsible for assuring that the number of NIOSH and Dosimeter replicates and blanks performed, the frequency of on-site inspection and inter-field team comparison performed by the testing field teams, and the number of split and dummy sample subbmitted periodically for laboratory analyses are as planned in the Test Protocols and QA/QC Specification and that they comply with the internal Quality Control Program.

AUDITING ALL ASPECTS OF THE PROJECT

QA/QC Contractor will audit all aspects of the project performed by the three levels of the project teams (project manager, local supervisor and field/analytical teams). A record of all auditing performed by the project manager and local supervisor shall be acquired by the QA/QC contractor.

18 September 81

Professional and Special Services Centre
Department of Supply and Services
Place du Portage, Phase III
Room 10B3
11 Laurier Street
Hull, Quebec
K1A 0S5

Attention: Mr. R.S. Mackey

Dear Mr. Mackey:

In response to the revised scope of the Quality Assurance/Quality Control, (QA/QC), for the national testing survey, as discussed with you and Mr. Youngson on September 17, 1981, Concord Scientific Corporation provides the following revisions to our proposal of August 31, 1981.

The technical revisions are based on the Consumer and Corporate Affairs document: "Outline of the Responsibilities of the QA/QC Contractor". A revised cost proposal is also included.

Training/Collaborative Testing (Weeks 1 and 2)

As QA/QC contractor, Concord Scientific will provide, in lieu of formal written testing and on-site inspections of training procedures, a certification requirement to be fulfilled by the contractors responsible for field and laboratory work. The formal certification procedure would consist of a form, listing training steps to be followed, and requiring the contractors to certify that their laboratory and field teams, (individuals names), have been trained according to the specifications and proven to be competent in the work. The certification will be verifiable by random on-site inspections of field team performance and the results of the inter-laboratory collaborative testing.

The certification procedure will also require that the contractor ensure field and analytical teams follow the specified test protocols precisely.

Contractors shall be requested to submit their summary operational field manual(s) to the QA/QC contractor for inspection. Preparation of these manuals is considered to be a useful training exercise, and will provide an indication of the level of understanding of the regional contractors.

Concord will supply to the contractors a brief "Trouble-Shooting Manual" by the end of the first week of the contract.

.. 2

Two batches of standard samples (as specified) will be submitted to contractors' laboratories by the beginning of the week prior to commencement of sampling. One batch is to be reported on by the end of that first week and the second by the end of the first week of sampling.

About 1% of NIOSH analytical samples (approximately 100, including blanks) will be split for duplicate analysis by the Concord Scientific laboratory. If four laboratories are involved, this will mean approximately 6 duplicates per laboratory per week.

Validation of Data (during course of survey)

The contractors shall be asked to report (orally) weekly the results of replicate sampling and blanks by their field teams. If the replicates differ regularly by more than 15%, this will be flagged to the project manager or the sub-contractor and to the UFFI Centre. Similar action will be taken if the blanks do not meet the specified criteria, and if the Dräger in-wall measurements relative to the NIOSH room air measurement fall outside of the specified bounds.

If necessary, corrective action will be initiated in response to these weekly reports, through discussions with the contractor, to identify causes of problems and steps to alleviate them.

As an additional check on data review being conducted by the contractors' local supervisors and the project manager, 10% of the home and lab data sheets will be reviewed by the QA contractor. This will provide a statistically valid sample to test the effectiveness of data validation at the local/regional level, but will avoid unnecessary duplication of effort.

Auditing Field Team Sampling Methods

Concord recommends that replicate sampling be carried out for one of the three NIOSH samples in each home tested during the first week of the survey. Teams that meet a criterion of 15% or less variation between replicates will then collect replicate samples according to the specification (10% of samples) thereafter. Teams not in compliance with that criterion must continue to collect a replicate sample in each house until such time as the criterion is met.

On-Site Inspections/QA Replicate Sampling

Concord will send a trained sampling/audit team (1 or 2 2-person teams deployed) on randomly chosen dates to run replicate NIOSH sampling, (3 samples) parallel with contractors' field teams, for a total of 20 teams and 20 homes. These numbers correspond to 40% of the teams and 1% of homes, a reasonable sample size to determine relative variability of team and lab performance. One member of the QA team will audit the 'home base' laboratory and review procedures with supervisory staff. [illegible]

Internal Quality Control Compliance/Auditing

As specified.

Concord Scientific Corporation is prepared to initiate the QA program immediately and to meet the following milestones:

- training certification and first-round collaborative laboratory testing complete by September 30, 1981
- weekly progress meetings/reports/review of QA results
- completion of QA analysis by October 31, 1981
- completion of QA data review and report by November 5, 1981, (with the exception of the QA results of the final few days' samples, since receipt of these samples is delayed by 2 to 3 days relative to their receipt by the contractors).

Conditions and Requirements

1. Timely receipt of detailed testing schedules from contractors
2. Timely transmittal of required samples by contractors
3. Provision of required laboratory data and reports of results by the contractor

The revised cost estimate is attached (Appendix A). I trust that these revisions meet your requirements.

Very truly yours,

CONCORD SCIENTIFIC CORPORATION

Robert B. Caton, Ph.D.
Director, Toxic Substances

Number/
Numéro

2

Concord Scientific Corporation
2 Tippett Road Downsview (Toronto), Ontario, Canada M3H 2V2
Tel (416) 630 6331

UFFI REFERENCE CENTRE
CENTRE DE DOCUMENTATION
DE LA MIUF

Protocol for Retesting

Procedures Manual for Repeat Sampling of Homes in Eastern Canada Insulated With Urea Formaldehyde Foam

Updated January 26, 1982

Addenda

Addition to the list of TEST HOMES:

312 Mr. Hubert Thomas (506) 832-7868
176 Main Street
Hampton, N.B.
E0G 1Z0

Addition to SAMPLE TRANSMITTAL/LAB REPORTING SHEET

- Include Lot # for each sample.

If it is necessary to re-use the adsorbent tube -

1. Wash tube and nipple ends in double distilled de-ionized organic-free water.

2. Dry at 90°C for one hour.

3. Prepare adsorbent tube with pre-conditioned molecular sieve and re-conditioned tubes.

UFFI REFERENCE CENTRE
CENTRE DE DOCUMENTATION
DE LA MIUF

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Summary of Requirements - UFFI Houses

1. House Preparation (See page 1)

2. Room Air For Formaldehyde (See page 2)
   (Oak Ridge molecular sieve active method)
   2 air samples collected indoors
   1 air sample collected outdoors
   1 blank per field team per day
   1 replicate sample every three houses

3. Temperature and Relative Humidity Measurements (See page 7)

4. Wind Speed and Direction Measurements (See page 7)

5. Barometric Pressure and General Weather Conditions
   (See page 7)

6. Passive Dosimeters (See page 7)
   (Berkeley treated filter method - 2 per home
   + 1 replicate where possibl
   (Dupont badge dosimeter - 2 per home
   + 1 replicate
   1 blank per home)

1.0 House Preparation

1.1 Eighteen Hour House Close-Up

The Contractor will instruct the homeowner to operate the house as follows for 18 hours before the test:

- ensure that the minimum house air temperature is 20°C. This means leaving the thermostat up overnight (no night set-back) during cold weather and leaving air conditioning devices off or on recirculation mode only, during warmer months. Provided that this minimum temperature is maintained, the heating system should be run in a normal operating mode.

- put humidifier on low setting;

- close all windows, fireplace vents, ~~or~~ and garage doors of attached garages.

During this 18 hour period the homeowner SHOULD NOT:

- operate vetilation devices such as kitchen and bathroom vent fans (ensure that their flappers are closed), air conditioning devices.

- generate any smoke by frying, broiling, smoking, etc.

- operate automobiles in attached garages or carports where fumes may collect.

- open doors between indoors and outdoors (if necessary, enter/exit quickly).

- open garage doors in attached garages.

- use paint, varnish, paint thinners, lacquers, air fresheners, or any aerosols.

1.2 Procedure On-Site Prior to Sampling

Prior to beginning any indoor tests, the Contractor should:

- enter the house quickly

- set the thermostat to 14°C immediately before beginning sampling to shut off the furnace during the test.

- check that all windows, vents, air conditioning, etc. have been closed, for the required time period.

- ~~ensure~~ check that no smoking, frying or pollutant inducing activities have taken place, and prevent them from taking place for the duration of the testing.

- ~~ensure~~ check that no automobiles were operated in attached garages or carports during the previous 18 hours (or since close-up) and that none are operated during the test period.

The contractor shall include in his report any ~~observed~~ detected non-compliance with preparation requirements

- perform a brief inspection to ensure that UFFI is present.

2.0 Room Air and Outdoor Formaldehyde Measurements

The procedure to be used for the determination of formaldehyde in air indoors and outdoors is to pull air through a bed of molecular sieve at a flow rate of 2 litres per minute for 15 minutes.

2.1 Sampling Locations

Where possible kitchens and bathrooms should not be used ~~as~~ for air sampling unless these are the only rooms with UFFI or the owner complains of particular problems in that location

Indoor: Two indoor sample locations will be selected as being representative of room air for each house. These should be in rooms most used by the homeowner and/or members of his family. In the case of a two storey dwelling, a sample should be taken on each floor; in a bungalow, a sample should be taken at each end of the main floor, ~~36" to 60"~~ 1.0 to 1.5 metres from the floor.

An appropriate stand to support the sorbent tube securely at this height should be used. If a home occupant complains of a specific problem area, note this and place a sorbent tube there.

Outdoor: An outdoor sample should be taken upwind of the house, as far away from major obstructions, roads, or driveways as possible, at least ten feet away from the house, and positioned at a height equivalent to that of the main floor level of the house. For the outside sample, protect the pump (and enclosed battery) from the weather with an enclosure which provides insulation but does not restrict exhaust airflow. If it should rain or snow during sampling, the sorbent tube should be protected with an inverted ~~metal~~ funnel ~~(crimped opening)~~.

with the narrow opening closed off.

Summary: Sampling requirements per house are as follows:

2 room air samples collected indoors
1 ambient air sample collected outdoors
1 blank per field team per day
1 replicate sample every ~~3 houses~~ 10 measurements

2.2 Sampling Procedure

The sampling train consists of a laboratory prepared sorbent tube, a six foot length of Tygon tubing and air pump (Dupont P4000).

Sampling Apparatus:

Pumps: Dupont P4000 - Safety Supply Canada Ltd.

Tygon tubing: 1/4" ID - MIN 3/8" O.D.

Sorbent Tubes:

Components are as follows (per sorbent tube) -

Drying tube - 1 x 10 cm polyethylene tube
- 2 x serrated tips

Molecular sieve - 1/16" pellets, 5 grams per tube

Silanized glass wool - 2 oz per tube

End caps - 2 x 9/32"

The molecular sieve must be preconditioned at 200°C for 4 hours and then cooled with dry air.

Sorbent tubes are to be prepared in a clean, formaldehyde free area. To construct the sorbent tubes, a ten mm plug of silanized glass wool is inserted (flush with end) into one end of the drying tube. Five grams of molecular sieve is poured into the other end. A second ten mm plug is added to the top of the sieve layer. It is important for sampling that the sieve be packed firmly in place between the plugs, at one end of the drying tube. The serrated tips are pushed onto the filled tubes, the end caps attached, and the tubes transported to the field.

Sampling Procedure:

1. Check the sorbent tubes to make certain the plugs are in place and the sieve is held firmly between the plugs. This is important, to maintain uniform airflow through the molecular sieve.

2. Ensure that pumps have been calibrated to a flow rate of two litres per minute.

3. Remove sorbent tube caps and attach Tygon tubing to the outlet end (the end packed with sieve) of the sorbent tube. Attach the other end of the tygon tubing to the pump and set the pump on the floor. The inlet end (the end with the air space) of the sorbent tube should be pointing down.

4. Gain access to the pumps control panel by loosening the two screws on the face of the pump.

5. Check to make certain that the timer control switches are properly set to run for exactly 15 minutes. A set of 8 control switches (white switches in a red background) is located at the bottom of the panel. They should be positioned as follows: —

Switch Numbers	1 - 5	OFF	(upper half depressed)
	6	ON	(lower half depressed)
	7	AUTO	(upper half depressed)
	8	NORM	(lower half depressed)

6. Check that the drive belt is in place.

7. Turn on the pump.

8. The pump will automatically shut off at the end of the required sampling period. Before manually turning the pump off, press the test button and observe the flow interruption light. If it lights, the sampling was incomplete. It is therefore necessary to repeat the sampling with a new sorbent tube.

9. Upon completion of sampling, cap the sorbent tube with the column end caps and tape securely.

10. Store and transport the used sorbent tubes at cold temperatures.

2.3 Calibration of P4000 Sampling Pumps

It is imperative that all sampling teams understand implicitly the operation of their air sampling pumps. Anyone who is to use these pumps must first have read the manufacturers instructions and the sections below.

All pumps are to be calibrated daily against a primary standard such as a bubble tube. A secondary standard such as a mass flow meter, is acceptable if it is calibrated weekly against a primary standard.

A pump record book, as outlined below, must be kept for the course of this survey.

Calibration Steps:

1. Assemble sampling train (pump, tubing, sorbent tube) as you would in the field.

2. Attach a second length of tubing from bubble tube to inlet end of sorbent tube.

3. Remove cover from pump and set control switches as follows (white switches on red background).

Switch No.		
1	ON	(lower half depressed)
2 - 5	OFF	(upper half depressed)
6	ON	(lower half depressed)
7	AUTO	(upper half depressed)
8	NORM	(lower half depressed)

4. Make certain drive belt is in low flow array.

5. Turn pump on and let it run for 5 - 10 minutes.

6. Wet walls of bubble tube with soap solution.

7. Using a stop watch measure the time it takes for a bubble to travel the length of the bubble tube.

8. Convert this value to cc/min.

9. Adjust flow rate (a bit at a time) with the needle value in the upper left corner of the pump.

10. Repeat until the flow is exactly two litres per minute.

11. Turn pump off.

12. Return rockerswitch number one to off position (upper half depressed).

13. The sorbent tube used for calibration should be replaced weekly or sooner if moisture is noticed in sorbent tube.

14. Set the time for a 15 minute sampling period and check it. (#5 Page 4)

Pump Record Book:

A record book is to be kept which provides the following information for each pump.

Pump #	Date	Sample No.	Sampling Time	Date Charged	Operating Time Since Last Charged	Date Calibrated.

Ni-Cd Battery Life:

The pumps provided for this survey (Dupont P4000) will operate for at least eight hours (at normal room temperature) before needing a charge if proper procedures are followed. Therefore a pump should last for approximately twenty-eight samplings (including calibration) before needing a charge. Outdoor sampling in cold weather will require well charged pump batteries. During prolonged storage periods in between use, the Ni-Cd batteries will gradually lose their charge.

It is important that the pumps be run for eight (8) hours before re-charging. Therefore, if 8 hours operation have not been completed, continue running the pump (during transit, etc). DO NOT run down completely — only 7-9 hours total.

It is also important that the pumps be full recharged for 14-16 hours before reuse. Charge time need not be continuous, but complete charge is required before re-use.

If these instructions are not followed, the batteries will develop a "memory" and their operational life will be severely altered.

NOTE: Care in handling the charger is required. The fine connecting wire breaks easily at the junction with the charger, and is not easily repaired. Do not handle the charger by the connecting wire; do not wrap the connecting wire around the charger.

3.0 Temperature and Relative Humidity

Temperature measurements, both wet bulb (T_{wb}) and dry bulb (T_{db}) are to be taken in the vicinity of each air sampler, using a psychrometer. The psychrometer is to be operated according to manufacturer's instructions. Repeat the procedure until a constant relative humidity is determined. (NOTE: where ambient temperature is below 0°C, use T_{db} only, and obtain outdoor relative humidity from the local weather station.

These temperature measurements are to be used to determine relative humidity in each location.

4.0 Windspeed and Direction Measurements

The direction and speed of the prevailing winds are to be noted, using a portable anemometer. The measurement is to be made upwind of the house and as free of nearby obstructions as possible. The anemometer is to be operated according to the manufacturer's instructions.

5.0 Barometric Pressure and General Weather Conditions

The nearest weather station is to be contacted for a report of local weather conditions. Where hourly readings are available, record measurements for the hour most central to the time period over which the house tests were conducted. Data is to be recorded in the appropriate area on the provided form. The reporting station is to be specified.

In addition, general weather conditions and precipitation are to be noted.

6.0 Field Deployment of Passive Monitors (Berkeley and Dupont

Select two locations for the passive monitors, in the rooms where active sampling was done, by the following criteria:

- Dosimeters must be left undisturbed for one week.

- Sites should be open and unobstructed to allow free air flow. The dosimeters should be at least one foot away from any large flat wall, and should not be placed in a closed corner of any kind.

- Dosimeters should be placed 1 to 2 meters above the floor.

- Dosimeters should be placed no closer than two feet to known sources of formaldehyde (such as combustion appliances, particle board surfaces).

Once the sampling sites have been selected:

I. BERKELEY DOSIMETER

1. Examine the dosimeter to be used. The cap should be securely in place and the vial should not be cracked. The treated filter should lie flat on the bottom of the dosimeter.

2. Fill in a sample label* with the house code and the sample number and/or location description. Put the same information on the data sheet provided for the Berkeley dosimeters.

3. Record the date and start time on the label* and the data sheet provided.

4. Separate the glass vial from the red top, turn the vial over, and reinsert it in the cap with the open end now exposed. Hang the dosimeter by its hook, using the string and fastener provided, from the ceiling or a high point in the room (lamp, bookcase, etc).

5. If a third dosimeter is available, place it beside the other in one location (replicate sample).

6. Leave in place for one week. Instruct the homeowner carefully in stopping the sampling, as follows:

    (a) Replace the red cap over the open end of the vial. Make sure it fits tightly and does not pop back up due to trapped air.

* It may be necessary to provide your own labels. Suggested format:

HOUSE CODE: ____ ____________

SAMPLE LOT # LOCATION: ____________

START DATE M T W T F S S

________ (d) ________ (mo)

STOP DATE M T W T F S S

________ (d) ________ (mo)

(b) Write the stop date and time in the space provided

(c) Return the dosimeters for analysis in the pre-addressed mailer provided (postage paid).

II. DUPONT DOSIMETER

1. Note the lot # on each dosimeter.

2. Check to ensure the fluid-filled bags are not punctured.

3. Smooth out the foil pouch. Replace all package parts in the mailing container.

4. Label the start date and time in the space provided.

5. Hang a dosimeter, using the string provided, beside the Berkeley dosimeter(s) in each of the two sampling sites.

6. Place a second Dupont dosimeter beside the first Dupont dosimeter in one location (replicate sample).

i.e. 2 Duponts 1 Berkeley in one location

1 Dupont 2 Berkeley's in the second location

7. Leave one Dupont dosimeter in each house as a blank sample, opened and immmediately resealed. Use the blank as a demonstration to the homeowner how to reseal the foil pouches.

8. Put the sample information on the data sheet provided for the Dupont dosimeters.

9. Leave in place for one week. Instruct the homeowner carefully in stopping the sampling, as follows:

(a) Note stop date and time on label space provided. (Important!)

(b) Place badge in foil pouch with the same number. Fold over the open edge of the pouch to seal it, and fasten with closure provided.

(c) Return the dosimeters for analysis in the pre-addressed mailing box provided.

7.0 Quality Assurance/Quality Control (QA/QC)

7.1 Field QA/QC

Quality assurance and quality control in the field sampling are specified by the following requirements:

(a) Strict sampling pump specifications (See Section 2.0);

(b) Strict pump calibration requirements (See also Section 2.0). A copy of pump calibration records shall be sent to the QA/QC supervisor.

(c) Sample Replicates:
In the active sampling method ten percent (10 %) of all field samples, or one sample in every three homes, for formaldehyde in room air, will have replicate sampling done (side-by-side). In the passive sampling methods every home will have a replicate sample of both methods. Replicates will be labelled such that they are indistinguishable from field samples.

(d) Sample Blanks:
Field blanks will be put aside for analysis, one per day per field team, for the active sampling method. For the Berkeley passive sampling method, blanks will be held by the laboratory doing the analysis. Field blanks for the Dupont passive sampling method will be done one per house, and will consist of having the foil pouch opened and then immediately resealed. It is to be left with the homeowner who is to be instructed to send it along with the remaining Dupont passive dosimeters.

7.2 Laboratory QA/QC

Quality assurance/quality control in the laboratory analysis are specified by the following requirements:

(a) Daily preparation of fresh Standard Solutions A and B from the Stock Solution (See Section 8.3);

(b) Daily preparation of a standard curve (See also Section 8.3);

(c) Preparation of a laboratory blank with each day's field samples;

(d) Interlaboratory QA/QC.

Participating laboratories will be provided with two formaldehyde solutions in three concentration ranges, for analysis by the pararosaniline method. The laboratory supervisor will split the samples into aliquots for duplicate analysis, to allow determination of reproducibility. Analytical results from these samples will be returned to the QA/QC contractor.

The laboratory supervisor will also split field samples, two from each field team, and send them to the QA/QC laboratory for analysis. Because the pararosaniline method does not involve stabilized solutions, it will be necessary to keep the samples cold but not frozen during shipping. A plastic thermos is recommended, with a temperature indicator to detect freezing.

8.0 Laboratory Analysis - Molecular Sieve

8.1 Reagents

Water - Double distilled de-ionized organic-free water

Pararosaniline - Stock PRA reagent from CEA, Westwood, N.J.

Sodium sulfite solution - Dissolve 0.10g anhydrous Na_2SO_3 in 100 ml double distilled de-ionized water

8.2 Method

1. Transfer sample molecular sieve (5 grams) and glass wool plugs to a glass stoppered 50 ml vial.
2. Add 13.5 ml water.
3. Rinse sieve with water for approximately 20 minutes.
4. Filter the rinse solution through Whatman #40 filter paper.
5. Take 3 ml aliquot of the filtrate.
6. Add 0.3 ml PRA to each aliquot.
7. Wait 10 minutes.
8. Add 0.3 ml sodium sulfite solution.
9. Cover the samples and wait 40 minutes.

10. Measure absorbance at 570 nm in comparison to analytical blank. NOTE: 1 cm cells are used.

11. Analytical blank is prepared by repeating the above procedure using unexposed sieve. Blank must be less than 0.2 AU.

12. Results in absorbance units, corrected for the analytical blank and the field blank, converted to µg formaldehyde with the curve.

8.3 Standard Curve

1. Reflux 20g paraformaldehvde in water for 1 hour, cool and filter the resultant solution, and dilute to 500 ml. The concentration should be approximately 40 mg/ml.

2. Standardize the solution using the sulphilte technique described by Walker, J. (1975. Formaldehyde. R.E. Krieger Publishing Company, Huntington, N.Y. pages 486-487), or as described below:

Place 50 ml of 1.0 M Na_2SO_3 in a 400 ml beaker. Stir the solution using a magnetic stirrer. Measure and record the pH, which should be between 7 and 9. Add 25.0 ml of the 40 mg/m formaldehyde solution to the beaker. The pH should now be about 12. Using the pH meter, titrate the solution back to its original pH with 1.00 N HCl. Approximately 30 ml will be needed. One ml of 1.00 N HCl is equivalent to 30.03 mg of formaldehyde.

Thus:

$$\text{Formaldehyde concentration (mg/ml)} = \frac{30.03 \times \text{ml HCl}}{25.0 \text{ ml}}$$

3. Standard Solution A is prepared by diluting 25 mL Stock Solution to one litre with water.

4. Standard Solution B is prepared by detecting 1.0 mL of Solution A to 100 mL with water.

5. The standard curve is prepared by pipetting Standard Solution B - 0.5 mL, 0.7 mL, 1.0 mL, 2.0 mL, and 2.5 mL - into 25 mL volumetric flasks. These are diluted to 25.0 mL with water.

6. A 3 mL aliquot of each standard is analyzed in the same way as sample aliquots.

7. The absorbance is plotted against micrograms of formaldehyde in the colour-developed solution (3 mL aliquot), the slope of the standard curve is 0.532 ± 0.037 AU mL ug^{-1}.

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THE REPORT
ON THE
NATIONAL TESTING SURVEY
TO THE
BOARD OF REVIEW
BY THE
UREA FORMALDEHYDE FOAM INSULATION INFORMATION AND COORDINATION CENTRE

December 14, 1981

1. INTRODUCTION

1. The UFFI/ICC was established in June 1981 to be the Government's Information and Coordination Centre for all UFFI related matters. Its tasks were and are to:

   a) coordinate federal government actions relating to UFFI,

   b) provide information and advice to the public concerning UFFI, and

   c) carry out a national testing survey involving 2,400 houses.

2. An objective of the national testing survey was to determine ambient formaldehyde levels, by a consistent method, for both indoor and outdoor air, in respect of a sufficiently large number of houses with UFFI and houses without UFFI, so that a valid statistical analysis could be made. At the request of the Board of Review this report presents this data.

II. NATIONAL TESTING SURVEY

A. METHODOLOGY

(i) House Selection

3. At an early stage of the program it was decided to begin by testing 100 houses in which individuals had reported serious health problems or that they had moved out of their houses. These houses were selected from information which the UFFI/ICC had on hand as of August, 1981.

4. From houses insulated under the CHIP program two groups were selected:

   (i) 1200 houses with UFFI; and

   (ii) 400 houses without UFFI (Control).

5. Another 700 houses were selected from UFFI/ICC files and Provincial records.

(ii) Test Procedure for Determining Indoor and Outdoor Formaldehyde Levels

6. The procedure for determining the levels of formaldehyde in the indoor air of houses, and in the outdoor air near these houses, was developed by the *NRC in consultation with Concord Scientific. The basic protocol for these tests was reviewed by representatives of **CCPA and they agreed with that protocol. Subsequent to the CCPA examination the sampling time was shortened from 3 hours to 2 hours and the analysis procedure was modified to maintain the same sensitivity in the measurements. This Technical Procedures Manual, and subsequent modifications, will be found in materials submitted with this report. (Tab 1)

7. The collection of air samples and the analysis thereof was done according to the NIOSH method, as modified by the Lawrence Berkeley Laboratories in the U.S., and as further refined by NRC and Concord Scientific. These modifications were introduced to improve the sensitivity of the collection process and the precision of the analytical procedure.

8. All homeowners, both of UFFI and non-UFFI houses, were asked to prepare their houses for testing of formaldehyde levels in the same way. This preparation is commonly referred to as the 18 hour close-up procedure and is fully described in the protocol. A few days before the technicians were to test the houses, the homeowners were contacted to review this procedure with them to ensure understanding and compliance therewith. In addition the technicians collecting the air samples were instructed to question the homeowners to determine that the necessary procedure had been followed.

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*National Research Council
**Canadian Chemical Producers Association

9. The outdoor air samples were collected for each house at a location upwind from the house, usually at a distance greater than 10 feet away from an exterior wall and at the level of the main floor of the house.

(iii) Quality Assurance/Quality Control (QA/QC)

10. A quality assurance program was conducted during the course of the National Testing Survey. This program included supervision of the internal quality control procedures of the members of the testing consortium. These procedures were based on the Technical Procedures Manual and QA/QC Specifications developed for the National Survey. These QA/QC Specifications will also be found in the materials at Tab 2. A draft report on the results of the quality assurance program accompanies this report.

11. In this QA/QC program particular attention was paid to the measurement of indoor and outdoor levels of formaldehyde. All major potential sources of random and systematic error were examined by:

(a) duplicate sampling of 10% of all samples taken by each field team in the consortium to determine the repeatability of the measurements; and

(b) duplicate analysis by a second laboratory on split samples of approximately 1% of the air measurements, in order to evaluate variations in day to day laboratory analysis; and

(c) replicate sampling on a side by side basis of 60 readings taken from 20 homes in order to evaluate the reproducibility in the measurements; and

(d) supplying each laboratory with blind samples containing known concentrations of formaldehyde, at regular intervals, in order to check the accuracy of their analytical procedures.

12. To summarize the results of this program over all laboratories:

(a) there was little systematic error in individual measurements except at low levels where the error was negative, and

(b) the random error, although relatively large in respect to any individual measurement, does not have a significant effect on the averages due to the large sample sizes.

13. The results of the QA program allowed the sources of error to be identified and their magnitude to be estimated. On this basis, poor data were identified and corrective field and laboratory actions initiated. In those cases where test results were outside the limits of acceptability based on the QA/QC protocols, the results were rejected from this report.

B. RESULTS

TABLE I

Groups of Houses Tested

CODE	SAMPLE GROUP	NO. OF HOUSES PER SAMPLE GROUP
1	Control houses from CHIP files	378
2	100 houses	100
3	UFFI Houses from UFFI/ICC files	651
4	UFFI Houses from CHIP files	1,146

TABLE II

Effect on overall results of formaldehyde levels which were below the limit of detection of the test procedure (c)

Code	Average of the average indoor levels when ND = 0[a] in ppm.	Average of the average indoor levels when ND = 0.01[b] in ppm.
1	0.034	0.035
2	0.139	0.139
3	0.040	0.041
4	0.054	0.054

a) For all tests where the formaldehyde levels were below the limit of detection of the test procedures, the levels were said to be not detectable and assigned the value N.D. For purposes of calculation, all results marked as ND were considered as zero.

b) The nominal limit of detection for the modified NIOSH test procedure employed was 0.01 ppm. For purposes of calculation all results marked as ND were considered to be equal to 0.01 ppm.

c) In all subsequent tables the data displayed is that obtained when all results marked ND were considered as zero for purposes of calculation since it is obvious from the table that this makes no meaningful difference in the results obtained.

TABLE III

Results for average indoor levels of formaldehyde

Code	Arithmetic means of the avg. indoor level (ppm)	Geometric means of the avg. indoor level (ppm)	% of avg. indoor levels $\geq$ 0.1 (ppm)	Avg. Outdoor level (ppm)
1	0.034	0.0278	2.6	0.007
2	0.139	0.0769	47	0.007
3	0.040	0.0317	5.1	0.008
4	0.054	0.0421	10.2	0.009

TABLE IV

Results for maximum indoor levels of formaldehyde

Code	Arithmetic means of the maximum indoor level (ppm)	Geometric means of the maximum indoor level (ppm)	% of the maximum indoor levels ≥ 0.1 ppm
1	0.042	0.034	4.8
2	0.174	0.104	57
3	0.048	0.037	8.6
4	0.067	0.052	16.5

TABLE V

Range of Average Indoor Formaldehyde Levels

RANGE	GROUPS			
	CONTROL CHIP	100	ICC RECORDS	UFFI CHIP
<.01	12.7	4.0	11.1	4.2
>.01 - .025	29.4	7.0	26.3	16.0
>.025 - .04	25.7	7.0	24.6	22.2
>.04 - .055	17.7	11.0	14.3	20.0
>.055 - .070	7.9	15.0	9.8	13.9
>.070 - .085	4.0	2.0	4.9	8.7
>.085 - .1	-	9.0	4.0	5.2
>.1 - .15	2.4	22.0	3.8	7.6
>.15 - .2	0.3	7.0	1.1	1.4
>.2	-	16.0	0.2	0.9

NOTE: Table III shows the percentage of houses which have formaldehyde levels equal to and above 0.1 ppm. Those percentages are obtained by using all the values in and above ranges greater than .1 - .15 as well as those 0.1 readings from the .085 - .1 range.

TABLE VI

Range of Maximum Indoor Formaldehyde Levels

RANGE	GROUPS			
	CONTROL CHIP	100	ICC RECORDS	UFFI CHIP
<.01	9.0	2.0	7.2	3.1
>.010 - .025	22.0	3.0	22.3	10.5
>.025 - .04	27.0	6.0	24.4	21.1
>.04 - .055	19.0	5.0	15.2	17.2
>.055 - .07	9.3	18.0	11.5	14.4
>.07 - .085	6.1	6.0	5.1	10.7
>.085 - .1	2.9	7.0	6.6	7.5
>.1 - .15	3.7	24.0	4.8	10.7
>.15 - .2	0.3	12.0	2.5	2.8
>.2	0.5	17.0	0.5	2.0

NOTE: Table IV shows the percentage of houses which have formaldehyde levels equal to and above 0.1 ppm. Those percentages are obtained by using all the values in and above ranges greater than .1 - .15 as well as those 0.1 readings from the .085 - .1 range.

TABLE VII

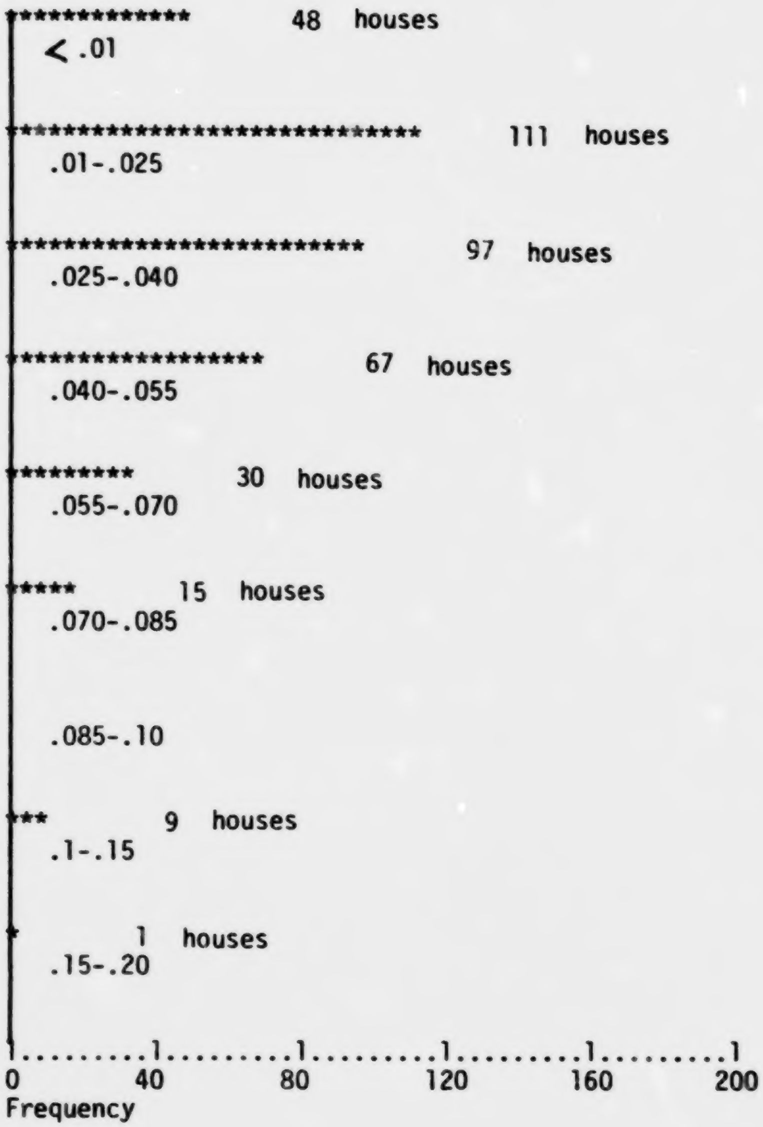
NATIONAL TESTING SURVEY

SUMMARY OF RESULTS

SAMPLE	NUMBER OF HOUSES	FORMALDEHYDE RESULTS				
		USING HOUSE AVERAGE INDOOR READINGS		USING HOUSE MAXIMUM INDOOR READINGS		AVERAGE OUTDOOR READINGS (ppm)
		AVERAGE (ppm)	% at or over 0.1 ppm.	AVERAGE (ppm)	% at or over 0.1 ppm.	
FIRST ONE HUNDRED	100	.139	47%	.174	57%	.007
UFFI CENTRE FILES	651	.040	5.1%	.048	8.6%	.008
UFFI CHIP	1,146	.054	10.2%	.067	16.5%	.009
CONTROL CHIP	378	.034	2.6%	.042	4.8%	.007

CHART 1 a

Distribution of Results for Average Indoor Levels of Formaldehyde in Control Houses from CHIP files (Code 1)



Total 378 houses

CHART 1 b

Distribution of Results for Average Indoor Levels of Formaldehyde in First 100 UFFI Houses (Code 2)

```
*****         4   houses
  <.01

********          7   houses
  .01-.025

********          7    houses
  .025-.040

************          11   houses
  .040-.055

****************          15   houses
  .055-.070

***        2   houses
  .070-.085

**********        9   houses
  .085-.10

***********************          22  houses
  .1-.15

********          7   houses
  .15-.20

*****************          16   houses
    .2

I.........I.........I.........I.........I.........I
0        10        20        30        40        50
Frequency

Total 100 houses
```

CHART 1 c

Distribution of Results for Average Indoor Levels of Formaldehyde in UFFI Houses from UFFI/ICC Files (Code 3)

```
***********************          72  houses
   < .01

**********************************************       171  houses
   .01-.025

*******************************************       160  houses
   .025-.040

*************************       93  houses
   .040-.055

******************       64  houses
   .055-.070

**********       32  houses
   .070-.085

*********       26  houses
   .085-.10

********       25  houses
   .1-.15

***       7  houses
   .15-.20

*       1  houses
   > .2

I.........I.........I.........I.........I.........I
0         40        80        120       160       200
Frequency

Total 651 houses
```

CHART 1 d

Distribution of Results for Average Indoor Levels of Formaldehyde in UFFI Houses from CHIP files (Code 4)

```
******          48  houses
 < .01

*******************        183  houses
 .01-.025

**************************        254  houses
 .025-.040

************************        229  houses
 .040-.055

*****************        159  houses
 .055-.070

***********        100  houses
 .070-.085

*******        60  houses
 .085-.10

**********        87  houses
 .1-.15

***        16  houses
 .15-.20

**        10  houses
 > .2

I.........I.........I.........I.........I.........I
0        100       200       300       400       500
Frequency
```

Total 1146 houses

CHART II a

Distribution of Results for Highest Indoor Levels of Formaldehyde in Control Houses from CHIP files (Code 1)

```
**********          34   houses
  <.01

**********************            84   houses
  .01-.025

***************************            102   houses
  .025-.040

*******************            72   houses
  .040-.055

**********          35   houses
  .055-.070

*******       23   houses
  .070-.085

****       11   houses
  .085-.10

*****       14   houses
  .1-.15

*         1    houses
  .15-.20

**          2   houses
 >  .2

l.........l.........l.........l.........l.........l
0        40        80        120       160       200
Frequency

Total 378 houses
```

CHART II b

Distribution of Results for Highest Indoor Levels of Formaldehyde in First 100 UFFI Houses (Code 2)

```
|***         2  houses
|   <.01
|
|
|****         3  houses
|  .01-.025
|
|
|*******         6  houses
|  .025-.040
|
|
|******         5  houses
|  .040-.055
|
|
|*******************           18  houses
|  .055-.070
|
|
|*******         6  houses
|  .070-.085
|
|
|********         7  houses
|  .085-.10
|
|
|*************************           24  houses
|  .1-.15
|
|
|*************         12  houses
|  .15-.20
|
|
|******************           17  houses
|   >.2
|
|
|1.........1.........1.........1.........1.........1
 0        10        20        30        40        50
 Frequency

 Total 100 houses
```

CHART II c

Distribution of Results for Highest Indoor Levels of Formaldehyde in UFFI Houses from UFFI/ICC Files (Code 3)

```
|*************          47   houses
|   < .01
|
|
|*************************************       145  houses
|   .01-.025
|
|
|*****************************************       159  houses
|   .025-.040
|
|
|**************************       99  houses
|   .040-.055
|
|
|**************************       75  houses
|   .055-.070
|
|
|*********       33  houses
|   .070-.085
|
|
|************       43  houses
|
|
|   .085-.10
|
|
|*********       31  houses
|   .1-.15
|
|
|*****       16  houses
|   .15-.20
|
|
|**       3   houses
|    >.2
|
|
|1.........1.........1.........1.........1.........1
 0        40        80       120       160       200
 Frequency

 Total 651 houses
```

CHART II d

Distribution of Results for Highest Indoor Levels of Formaldehyde in UFFI Houses from CHIP files (Code 4)

```
|*****          35   houses
|   < .01
|
|
|*************        120   houses
|   .01-.025
|
|
|*************************       242   houses
|   .025-.040
|
|
|*********************       197  houses
|   .040-.055
|
|
|******************       165   houses
|   .055-.070
|
|
|*************        123   houses
|   .070-.085
|
|
|**********              86   houses
|   .085-.10
|
|
|*************        123   houses
|   .1-.15
|
|
|****       32   houses
|   .15-.20
|
|
|***       23  houses
|   > .2
|
|
|1.........1.........1.........1.........1.........1
 0        100       200       300       400       500
 Frequency

 Total 1146 houses
```

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4

SUPPLEMENT NO. 1 TO
THE REPORT
ON THE
NATIONAL TESTING SURVEY
TO THE
BOARD OF REVIEW
BY THE
UREA FORMALDEHYDE FORM INSULATION INFORMATION AND COORDINATION CENTRE

December 30, 1981

Indoor Average Means and Geometric Means with Associated Standard Errors

Group	Mean	Standard Error	Log Scale (geometric mean)	Standard Error
1	0.034	.0015	-3.565	.0420
2	0.139	.0281	-2.561	.1131
3	0.040	.0014	-3.469	.0338
4	0.054	.0013	-3.159	.0236

Tests of Significance

To compare two averages to see if they are statistically significantly different, the following formula was used.

$$Z = \frac{\text{mean group i} - \text{mean group j}}{\sqrt{\left(\begin{matrix}\text{standard error}\\ \text{group i}\end{matrix}\right)^2 + \left(\begin{matrix}\text{standard error}\\ \text{group j}\end{matrix}\right)^2}}$$

The value of Z was compared to tables for a standard normal variable and the observed significance level was calculated. This analysis is valid because the means for each group are based on a large number of individual observations. A one-side test was used in all cases.

Comparisons	Value of Z for means	Significance level	Value of Z (geometric mean)	Significance Level
Group 2 vs. Group 1	3.73	.0003	8.32	.0000
Group 3 vs. Group 1	2.92	.0020	1.78	.040
Group 4 vs. Group 1	10.07	.0000	8.42	.0000

NOTE:

In the analysis on the log scale the non-detectable values were coded as .01.

SUPPLEMENTARY TABLE V

RANGE OF AVERAGE INDOOR FORMALDEHYDE LEVELS

RANGE	GROUPS			
	CONTROL CHIP	100	ICC RECORDS	UFFI CHIP
> .2 - .215		1	.15	.09
>.215 - .230		2		.26
>.230 - .245		1		.09
>.245 - .260		2		.17
>.260 - .275		1		
>.275 - .290		4		
>.290 - .305				.09
>.305 - .320				
>.320 - .335		1		.09
>.335 - .350				
>.350 - .365		1		
>.365 - .380				
>.380 - .395				
>.395 - .410		1		
>.410 - .425				.09
>.425 - .440				
>.455 - .470		1		
> 1.0		1		

SUPPLEMENTARY TABLE VI

RANGE OF MAXIMUM INDOOR FORMALDEHYDE LEVELS

RANGE	GROUPS			
	CONTROL CHIP	100	ICC RECORDS	UFFI CHIP
>.2 - .215			.15	.35
>.215 - .230		1		.17
>.230 - .245	.26	1	.15	.26
>.245 - .260		1		
>.260 - .275	.26	3		.26
>.275 - .290				
>.290 - .305		4		.17
>.305 - .320		1		.17
>.320 - .335				.09
>.335 - .350				
>.350 - .365			.15	
>.365 - .380				.17
>.380 - .395		1		
>.395 - .410				
>.410 - .425				
>.425 - .440		2		.17
>.455 - .470		1		
>.470 - .485		1		
>.650 - .665				.09
>.815 - .830				.09
>.995 - 1.01		1		
4.2		1		

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Annex III

Annexe 5

The Analysis of the U.F.F.I. Telephone Survey Data

REFERENCE CENTRE
CENTRE DE DOCUMENTATION
DE LA MIUF

R.J. MacKay and C.I. Young

Department of Statistics

University of Waterloo

November, 1981.

UFFI REFERENCE CENTRE
CENTRE DE DOCUMENTATION
DE LA MIUF

Introduction

This report discusses the analysis of the data collected by the U.F.F.I. Information and Coordination Centre. The data were gathered by telephoning more than 3000 households selected from records supplied by C.M.H.C.

The households were divided in two groups; those which had received a C.H.I.P. grant for the installation of rigid wall insulation and those which had received a C.H.I.P. grant for some other purpose. It was hoped that most of the homes which had used urea formaldehyde insulation would be in the first group.

The data collected by phone were coded onto mark-sense computer cards and sent to Waterloo to be processed and analyzed. The questions of interest are outlined in a letter to the authors (appendix 1).

The Data

A total of 3306 cards were received, with 2695 corresponding to homes from the rigid wall file and 611 from the other group (hereafter referred to as the control group). Of the total, there were a number of replicate cards and other problem cards. Corrections were made if possible (one card was deleted from a duplicate pair, for example). In seventy cases, correction was not possible and these cards were deleted from the analysis. A total of 2654 households from the rigid wall file and 548 households from the control file were included in the final analysis.

Some of the cards were not completed in all fields and hence some of the tables given below show missing values.

The Analysis

The homes telephoned (and responding) were selected from a list of homes which had been selected at random from the C.M.H.C, files. The statistical analysis and the estimation of confidence limits are based on the assumption that the selected homes constitute a random sample from the original files.

For all questions, the analysis is given for the data for each province and then in total for the entire country. For homes from the control file, there was insufficient data from all provinces except Ontario and Quebec to make any sensible conclusions.

Province	Number of homes in rigid wall file analyzed	Number of homes in control file analyzed
Alberta	75	2
British Columbia	72	47
Manitoba	172	24
New Brunswick	186	16
Newfoundland	101	11
Ontario	1090	224
Quebec	878	216
Saskatchewan	80	8
Total	2654	548

Table 1 Number of homes for which data is available by province

Where possible 95% confidence limits are given for the estimated values.

Question 1

To estimate the number of homes with U.F.F.I. in the rigid wall file, the proportion of homes with U.F.F.I. in the sample from a given province was calculated and multiplied by the total number of homes from that province in the file (see appendix 1).

Province	Estimated number of homes with UFFI	Confidence limits
Alberta	505	±131
British Columbia	1640	±219
Manitoba	3313	±268
New Brunswick	4285	±292
Newfoundland	478	±115
Ontario	14415	±718
Quebec	3753	±363
Saskatchewan	761	±165
Total	29150	±954

Table 2 The estimated number of homes with UFFI in the rigid wall file

Question 2

Since the sample sizes from the control file are much smaller, it is impossible to estimate precisely the number of homes with U.F.F.I. An extra complication is also added because the total number of homes from each province in the complete file must be estimated. This estimation was possible because we had a sample of 7535 randomly chosen homes from the file of 851,187 homes in the complete file.

Province	Estimated number of homes in the file	Confidence limits
Alberta	59427	±4998
British Columbia	70951	±5421
Manitoba	42480	±4270
New Brunswick	23274	±3198
Newfoundland	33108	±3792
Ontario	480614	±9724
Quebec	110494	±6592
Saskatchewan	30166	±3626
Yukon	565	± 505
Total	851187	

Table 3 Estimated number of homes in the control file by province

The number of homes with U.F.F.I. was estimated only for Ontario, Quebec, and all the rest. These estimates are very imprecise and should be used with care. They do show however that there is a strong possibility of a substantial number of homes in the control file having U.F.F.I.

Province	Estimated number of homes with UFFI	Confidence limits
Ontario 11 of 224 = 4.9%	26000 (5%)	±15000
Quebec 31 of 216 = 14.4%	17200 (16%)	± 6000
Other 7 of 108 = 6.5%	17000 (7%)	±13000
Total 49 of 548 = 8.9%	82000 (9.6%)	±22000

Table 4 Estimated number of homes in the control file with UFFI

Question 3

The following table gives the percentage of households in the sample having U.F.F.I. who were unwilling to be included in the testing programme. A dash indicates there were no homes with U.F.F.I. in that province that were sampled.

The numbers in parantheses are the number of homes with U.F.F.I. in the sample.

Province	Rigid Wall	Control
Alberta	3% (34)	-
British Columbia	2% (54)	-
Manitoba	13% (133)	0% (1)
New Brunswick	4% (153)	33% (3)
Newfoundland	10% (41)	0% (3)
Ontario	6% (645)	18% (11)
Quebec	4% (283)	6% (31)
Saskatchewan	0% (40)	-
Total	5.7% (1383)	10% (49)

Table 5 The percentage of UFFI homes who were unwilling to be tested

Question 4

The date of installation was not available from C.M.H.C. and this question was changed to use the date of application for a C.H.I.P. grant.

For the homes from the rigid wall file, the percentages are given in table 6.

Province	1977	1978	1979	1980	1981	Total
Alberta	-	22% (9)	19% (16)	22% (9)	-	21% (34)
B.C.	55% (11)	56% (16)	50% (18)	45% (9)	-	54% (54)
Man.	33% (6)	19% (36)	32% (69)	10% (19)	-	25% (130)
N.B.	0% (3)	44% (18)	22% (81)	37% (51)	-	31% (153)
Nfld.	-	0% (2)	33% (21)	39% (18)	-	34% (141)
Ont.	13% (30)	24% (104)	32% (303)	23% (205)	0% (1)	27% (643)
Que.	0% (1)	27% (26)	37% (116)	31% (142)	-	33% (285)
Sask.	0% (2)	40% (5)	22% (18)	33% (15)	100% (1)	29% (141)
Total	23% (53)	28% (216)	31% (651)	29% (468)	50% (2)	30% (1381)

Table 6 Of those homes with UFFI, the percentages reporting medical problems by year of application

There is no trend in the percentages over time.

For homes in Ontario and Quebec from the control file the data are given in table 7.

Province	1977	1978	1979	1980	1981	Total
Ontario	-	0% (1)	60% (5)	0% (5)	-	27% (11)
Quebec	-	1% (1)	17% (12)	15% (20)	-	15% (33)

Table 7 Of those homes with UFFI in the control file, the percentage reporting medical problems by year of application

Question 5

To answer this question only households with U.F.F.I. were considered. For those homeowners who reported a medical problem, the percentage not willing to be included in the testing programme was calculated. A similar comparative figure was calculated for those not reporting medical problems. Only the rigid wall file data was included. The numbers in parantheses are the denominators of the percentages.

	percentage not willing to be tested	
Province	not reporting medical problems	reporting medical problems
Alberta	4% (26)	0% (7)
B.C.	0% (25)	3% (28)
Man.	18% (97)	0% (33)
N.B.	5% (105)	2% (48)
Nfld.	12% (126)	7% (14)
Ont.	7% (466)	2% (173)
Que.	4% (188)	2% (92)
Sask.	0% (29)	0% (11)
Total	7% (962)	2.2% (406)

Table 8 The percentage of homeowners not willing to be tested by reported medical problems

The only province with significant differences in the percentages is Manitoba. Overall, the percentage is different but the number of homes is small enough that no bias should result. In the analysis of the data from the testing programme, it would be wise to take into account whether or not a medical problem was reported during the telephone survey.

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

Urea Formaldehyde
Foam Insulation
Information and
Co-ordination Centre

La mousse isolante
d'urée-formaldéhyde
Centre d'information
et de coordination

UFFI
MIUF

Place du Centre
200, Promenade du Portage
Hull (Québec)
K1A 0C9
(819) 994-0921

November 2, 1981

Mr. R.J. MacKay
Faculty of Mathematics
Department of Statistics
University of Waterloo
Waterloo, Ontario N2L 3G1

Dear Jock,

Further to our telephone conversation of October 28, I am enclosing the computer cards we discussed. I am also enclosing the "Operator Inquiry Procedure" and the "Documentation" instructions for the operators as per your request.

The telephone inquiry was implemented using:

(1) your 8000 randomly selected homes from the "Rigid Insulation In Walls" (RIIW) CHIP file as of March 1, 1981, of which there are a total of 50,770 members and

(2) your 7535 randomly selected homes from the total CHIP file as of March 1st, minus the members on the RIIW file, of which there are a total of 901,957 minus 50,770 = 851,187. This is known as the control file.

Since your selection was random, you will be able to get the Provincial breakdown of the total files from the distribution of the random sample. Although I don't have the Provincial breakdown of the total CHIP file, the following is the breakdown for the 50,770 members of the RIIW file, which you may wish to use as a check on your own projections.

..../2

Canada

Province	Grants for RIIW
British Columbia	2,186
Alberta	1,133
Saskatchewan	1,467
Manitoba	4,235
Ontario	24,025
Quebec	11,337
New Brunswick	5,209
Newfoundland	1,166
Yukon	3
North West Territories	9
Total	50,770

As we discussed by telephone, we would like you to provide us with the following information with the figures broken down by Province:

(1) The number of UFFI homes in the "Rigid Insulation in Walls" file;

(2) The number of UFFI homes in the control file, in those Provinces where enough homes were called to make a valid assessment;

(3) The percentage of people who have UFFI but who don't want to be tested;

(4) The percentage of people who have UFFI and who have:

  a. no medical problems
  b. medical problems and installed UFFI in 1980
  c. medical problems and installed UFFI in 1979
  d. medical problems and installed UFFI in 1978;

(5) The weighting factor, if any, in favour of those UFFI homeowners with medical problems compared to those without medical problems, who agree to have their house tested.

You informed me that you would require not more than one week to provide this information and that the maximum cost would be as follows:

1 day	J. MacKay	$350.00	
2 days	C. Young	$260.00	
Computer Time		$500.00	approx.
		$1110.00	

.../3

Since your own existing contract with this centre has 3 days outstanding, which have not been used, your 1 day of time can be billed to this contract.

The contracts with C. Young and the Computer Centre presently being drawn up are being increased by $260 and $1000 respectively to allow for this extra work.

Please let me know when you have the information set out in paragraphs 1 to 5. I would also appreciate your letting me know of any additional comments and suggestions you might have.

Yours sincerely,

S. Hall

S.F. Hall

SFH/dh

MacKay and Young Consulting

47 Timberlane Cr.
Kitchener, Ont. N2N 1T5
(519) 745-5484

APR AVR 13 1982

April 8, 1982

Mr. Douglas Youngson
UFFI Information & Coordination Centre
Place du Centre, 4th Floor
200 Promenade du Portage
Hull, Quebec
K1A 0C9

Dear Doug:

Please find enclosed two copies of our report on the analysis of the UFFI National Survey Data. I hope we have been able to answer some questions of interest. I feel we have in fact raised more questions that we have answered.

Although we have not yet added up the time we have spent, I think there are still a few days left on the allotment in our contract. If you have any follow-up questions, let us know and we can run-off some further analysis if necessary.

We plan to clean up the tape and complete the merging of the fungal counts and Dupont measurements next week. We will return the altered tape directly to Jacques St. Dennis.

Yours sincerely,

Jack

R.J. MacKay

RJM:mk

Encl.

⑨

Ian [illegible] retention pls BF with [illegible] conclusions and [illegible] analysis

Greg

THE ANALYSIS OF THE NATIONAL TESTING SURVEY DATA

A report by MacKay and Young Consulting
prepared for the UFFI Information and
Coordination Centre

R.J. MacKay
C.I. Young
Waterloo, Ontario
April 8, 1982

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INTRODUCTION

Preparation of Input Data

A computer tape containing information on 2426 homes was prepared by the UFFI Centre and forwarded to us. This tape contained all pertinent information (minus Dupont and Fungal counts) on these homes, in a format specified by the UFFI Centre. A preliminary listing of the file showed that approximately ten numeric values in the file did not conform to this format. Basically these numeric fields contained 'S' or '<' values and were recorded as missing information. Preliminary analyses listing means, minimums, maximums, etc. showed additional data errors. These are summarized in table 0.1. Again, any data errors were recorded as missing and subsequently ignored.

Dupont and Fungal counts were keypunched and verified by MacKay and Young Consulting from the data sheets provided by the UFFI Centre. Many house numbers did not match those on the computer tape and were thus ignored.

Table 0.1

Data Errors

1. Barometric Pressues less than 500 mmHg.
2. Wind speeds in excess of 30 km/hr.
3. External temperatures in excess of 30° C.
4. External humidity of 10%.
5. Study dates which preceeded UFFI installation dates.
6. Moisture barrier coded incorrectly.

One question which was of interest but unfortunately unusable, was whether or not an air intake had been installed on the furnace. Roughly 25% of the homes responded affirmatively and on examination of survey sheets it became clear that some homes took this question to mean an internal cold air return rather than an external air intake. A complete list of the variables used in the analyses is given in Appendix 1. Other variables defined implicitly do not appear here but are available if necessary.

Section 1. Summary Statistics

This section presents a series of tables containing the following information.

Table 1.1: a summary of the results for each province comparing UFFI versus non-UFFI homes.

Table 1.2: a table constructed by province to give for each group:

- (i) average of the average NIOSH readings,
- (ii) average of the maximum NIOSH readings,
- (iii) average of the average DRAEGER readings,
- (iv) average of the maximum DRAEGER readings,
- (v) proportion of homes with average NIOSH reading exceeding 100 ppb,
- (vi) proportion of homes with maximum NIOSH reading exceeding 100 ppb,
- (vii) percentage of homes with at least one Draeger sample classified D or E,
- (viii) percentage of homes with at least one Draeger sample classified E.

For each of these averages or proportions, the corresponding sample size and standard error are also given.

Table 1.3: a table corresponding to table 1.2 constructed for Canada.

Tables

Group 1

1 ≡ non-UFFI control homes
2 ≡ first one hundred homes
3 ≡ UFFI homes from ICC records
4 ≡ homes selected from CHIP
5 ≡

NIOSH: level of formaldehyde (ppb) by the NIOSH method.

MAXNIOSH: the maximum NIOSH reading (ppb) in each home.

AVDRAEG: the average Draeger reading (ppm) in each home.

MAXDRAEG: the maximum Draeger reading (ppm) in each home.

% Average NIOSH GT 100: percentage of homes in which the average NIOSH reading exceeded 100 ppb.

% MAXNIOSH GT 100: percentage of homes in which the maximum NIOSH reading exceeded 100 ppb.

% with D or E: percentage of homes in which at least one Draeger reading was classified as D or E.

% with E: percentage of homes in which at least one Draeger reading was classified as E.

N ≡ number of houses used in calculating the mean.

Mean ≡ average of the corresponding quantity.

Standard error of the mean ≡ the standard error associated with the given mean,

95% confidence intervals for the mean are given by ±2 standard errors.

Charts

$$G = \begin{cases} 1 & \text{home without UFFI} \\ 2 & \text{home with UFFI} \end{cases}$$

For NIOSH and Draeger readings the vertical scale has the interpretation

Class	Range of values NIOSH (ppb)	Range of values Draeger (ppm)
1	[0,20]	[0,.5]
2	[20,40]	[.5,1.0]
3	[40,60]	[1.0.1.5]
4	[60,80]	[1.5,2.0]
5	[80,100]	[2.0,2.5]
6	[100,120]	[2.5,3.0]
7	[120,140]	[3.0,3.5]
8	[140,160]	[3.5,4.0]
9	[160,180]	[4.0,4.5]
10	>180	>4.5

The horizontal scale is the percentage of homes within the particular group in a given class of readings.

	UFFI Homes				Control Homes	
Province	Av. NIOSH	%GT 100	Av. Draeger	%E	Av. NIOSH	%GT 100
Nfld.	59.9	13	3.27	65	37.3	0.0
P.E.I	44.8	0	1.31	9	30.3	0.0
N.S.	75.9	18	2.27	28	52.0	6.0
N.B.	60.9	14	2.71	44	38.3	0.0
Que.	39.0	6	1.74	29	26.2	1.5
Ont.	67.3	16	2.23	38	43.7	5.0
Man.	40.4	2.8	2.91	48	34.7	4.5
Sask.	39.3	0.0	2.56	45	33.8	0.0
Alta.	51.8	5.6	2.28	27	29.3	0.0
B.C.	39.1	1.4	3.07	53	30.5	0.0
Canada	53.7	10.3	2.25	37.4	35.5	2.85

Table 1.1 A Summary of UFFI versus Non-UFFI homes.

```
NEWFOUNDLAND SUMMARY
GROUP1=1

VARIABLE   LABEL                          N         MEAN          STD ERROR
                                                                   OF MEAN

NIOSH                                     9    32.77777778       5.34121235
MAXNIOSH                                  9    37.33333333       5.95818764
AVDRAEG                                   0         .                .
MAXDRAEG                                  0         .                .
BN         % AVNIOSH GT 100               9     0.00000000       0.00000000
BBN        % MAXNIOSH GT 100              9     0.00000000       0.00000000
DE         % WITH D OR E                  0         .                .
E          % WITH E                       0         .                .

GROUP1=3 --------------------------------------------------------------------

NIOSH                                    12    62.16666667      12.84498684
MAXNIOSH                                 12    72.83333333      13.79823953
AVDRAEG                                  12     2.40865741       0.41915654
MAXDRAEG                                 12     6.26666667       1.23025825
BN         % AVNIOSH GT 100              12    16.66666667      11.23666437
BBN        % MAXNIOSH GT 100             12    16.66666667      11.23666437
DE         % WITH D OR E                 12    50.00000000      15.07556723
E          % WITH E                      12    50.00000000      15.07556723

GROUP1=4 --------------------------------------------------------------------

NIOSH                                    34    59.13235294       5.61761731
MAXNIOSH                                 34    66.58823529       5.85735329
AVDRAEG                                  34     3.57774977       0.27952754
MAXDRAEG                                 34     6.77941176       0.40780661
BN         % AVNIOSH GT 100              34    11.76470588       5.60860347
BBN        % MAXNIOSH GT 100             34    14.70588235       6.16521341
DE         % WITH D OR E                 34    73.52941176       7.67989659
E          % WITH E                      34    70.58823529       7.93176309
```

```
NEWFOUNDLAND SUMMARY
G=1

PERCENTAGE BAR CHART
                                                                     FREQ  CUM.   PERCENT    CUM.
  N    AVERAGE WIDSH                                                        FREQ             PERCENT

       I                                                                2      2    22.22      22.22
  1    I**********************
       I                                                                4      6    44.44      66.67
  2    I********************************************
       I                                                                3      9    33.33     100.00
  3    I*********************************
       I
       -----+----+----+----+----+----+----+----+----
            5   10   15   20   25   30   35   40

                       PERCENTAGE
```

NEWFOUNDLAND SUMMARY
S=2

```
PERCENTAGE BAR CHART
                                                             FREQ  CUM.   PERCENT    CUM.
 CH   AVERAGE NIDSH                                                FREQ              PERCENT
         I                                                      6     6    13.04     13.04
  1      I*****************
         I                                                      6    12    13.04     26.09
  2      I*****************
         I                                                     15    27    32.61     58.70
  3      I*******************************************
         I                                                     10    37    21.74     80.43
  4      I*****************************
         I                                                      3    40     6.52     86.96
  5      I*********
         I                                                      3    43     6.52     93.48
  6      I*********
         I                                                      2    45     4.35     97.83
  8      I******
         I                                                      1    46     2.17    100.00
  9      I***
         I
         ----+---+---+---+---+---+---+---+---+---+---
             3   6   9  12  15  18  21  24  27  30

                       PERCENTAGE
```

```
NEWFOUNDLAND SUMMARY
G=1

PERCENTAGE BAR CHART

  EM    MAXIMUM NIOSH                                              FREQ   CUM.    PERCENT     CUM.
                                                                          FREQ               PERCENT
       I
  1    I******************************                                2      2     22.22     22.22
       I
  2    I********************************************                  3      5     33.33     55.56
       I
  3    I********************************************                  3      8     33.33     88.89
       I
  4    I***************                                               1      9     11.11    100.00
       I
       ----+---+---+---+---+---+---+---+---+---+---+
           3   6   9  12  15  18  21  24  27  30  33

                       PERCENTAGE
```

```
NEWFOUNDLAND SUMMARY
G=2

PERCENTAGE BAR CHART

  BN     MAXIMUM NIOSH                                                      FREQ   CUM.    PERCENT     CUM.
                                                                                   FREQ               PERCENT
         |
   1     |***************                                                     5      5      10.87      10.87
         |
   2     |***************                                                     5     10      10.87      21.74
         |
   3     |******************************************                         14     24      30.43      52.17
         |
   4     |******************                                                  6     30      13.04      65.22
         |
   5     |***************************                                         9     39      19.57      84.78
         |
   6     |******                                                              2     41       4.35      89.13
         |
   7     |******                                                              2     43       4.35      93.48
         |
   8     |***                                                                 1     44       2.17      95.65
         |
   9     |******                                                              2     46       4.35     100.00
         |
         ----+----+----+----+----+----+----+----+----+----+-
             3    6    9   12   15   18   21   24   27   30

                      PERCENTAGE
```

```
G=2

PERCENTAGE BAR CHART

CD    AVERAGE DRAEGER                                              FREQ   CUM.    PERCENT     CUM.
                                                                          FREQ             PERCENT
      |
 1    |*********                                                      2      2      4.35      4.35
      |
 2    |****                                                           1      3      2.17      6.52
      |
 3    |*****************                                              4      7      8.70     15.22
      |
 4    |**************************                                     6     13     13.04     28.26
      |
 5    |*************                                                  3     16      6.52     34.78
      |
 6    |**************************                                     6     22     13.04     47.83
      |
 7    |*****************                                              4     26      8.70     56.52
      |
 8    |**************************                                     6     32     13.04     69.57
      |
 9    |*****************                                              4     36      8.70     78.26
      |
10    |*******************************************                   10     46     21.74    100.00
      |
      ----+---+---+---+---+---+---+---+---+---+---
          2   4   6   8  10  12  14  16  18  20

                  PERCENTAGE
```

```
NEWFOUNDLAND SUMMARY
G=2

PERCENTAGE BAR CHART

 MD   MAXIMUM DRAEGER                                FREQ   CUM.   PERCENT     CUM.
                                                            FREQ             PERCENT
      |
  1   |*                                                1      1      2.17      2.17
      |
  3   |*                                                1      2      2.17      4.35
      |
  4   |*                                                1      3      2.17      6.52
      |
  6   |**                                               2      5      4.35     10.87
      |
  8   |***********                                     10     15     21.74     32.61
      |
 10   |**********************************              31     46     67.39    100.00
      |
      -----+----+----+----+----+----+----
          10   20   30   40   50   60

               PERCENTAGE
```

```
PRINCE EDWARD ISLAND SUMMARY
GROUP1=1
                                                                STD ERROR
VARIABLE   LABEL                         N        MEAN          OF MEAN

NIOSH                                    2    30.25000000     6.25000000
MAXNIOSH                                 2    39.00000000    14.00000000
AVDRAEG                                  0          .              .
MAXDRAEG                                 0          .              .
BN         % AVNIOSH GT 100              2     0.00000000     0.00000000
BBN        % MAXNIOSH GT 100             2     0.00000000     0.00000000
DE         % WITH D OR E                 0          .              .
E          % WITH E                      0          .              .
-------------------------------------------------------------------------
GROUP1=3 -----------------------------------------------------------------

NIOSH                                   11    44.81818182     6.68011729
MAXNIOSH                                11    56.54545455    10.25968601
AVDRAEG                                 11     1.30653811     0.26091661
MAXDRAEG                                11     3.42727273     0.49783000
BN         % AVNIOSH GT 100             11     0.00000000     0.00000000
BBN        % MAXNIOSH GT 100            11     9.09090909     9.09090909
DE         % WITH D OR E                11     9.09090909     9.09090909
E          % WITH E                     11     9.09090909     9.09090909
```

```
PRINCE EDWARD ISLAND SUMMARY
G=1

PERCENTAGE BAR CHART

CN   AVERAGE NIOSH                                            FREQ   CUM.   PERCENT     CUM.
                                                                     FREQ             PERCENT
       |
  2    |**************************************************      2      2    100.00     100.00
       |
       ----+----+----+----+----+----+----+----+----+----+
          10   20   30   40   50   60   70   80   90  100

                          PERCENTAGE
```

```
PRINCE EDWARD ISLAND SUMMARY
S=2

PERCENTAGE BAR CHART

  N    AVERAGE NIOSH                       FREQ   CUM.   PERCENT    CUM.
                                                  FREQ             PERCENT
       I
  2    I***************************          6      6     54.55     54.55
       I
  3    I*********                            2      8     18.18     72.73
       I
  4    I**************                       3     11     27.27    100.00
       I
       -----+----+----+----+----+--
           10   20   30   40   50

               PERCENTAGE
```

```
PRINCE EDWARD ISLAND SUMMARY
G=1

PERCENTAGE BAR CHART

 CHN    MAXIMUM WIDTH                         FREQ   CUM.    PERCENT     CUM.
                                                     FREQ              PERCENT
        |
   2    |*************************              1       1     50.00      50.00
        |
   3    |*************************              1       2     50.00     100.00
        |
        -----+----+----+----+----+
            10   20   30   40   50

                PERCENTAGE
```

```
PRINCE EDWARD ISLAND SUMMARY
G=2

PERCENTAGE BAR CHART

CMN   MAXIMUM NIOSH                      FREQ   CUM.    PERCENT     CUM.
                                                FREQ              PERCENT
      I
  2   I***********************             5      5      45.45     45.45
      I
  3   I*********                           2      7      18.18     63.64
      I
  4   I*****                               1      8       9.09     72.73
      I
  5   I*********                           2     10      18.18     90.91
      I
  7   I*****                               1     11       9.09    100.00
      I
      -----+----+----+----+---
          10   20   30   40

              PERCENTAGE
```

```
PRINCE EDWARD ISLAND SUMMARY
G=2

PERCENTAGE BAR CHART

CD    AVERAGE DRAEGER                                   FREQ   CUM.   PERCENT    CUM.
                                                               FREQ              PERCENT
      |
 1    |*********                                          1      1      9.09      9.09
      |
 2    |************************************               4      5     36.36     45.45
      |
 3    |***************************                        3      8     27.27     72.73
      |
 4    |******************                                 2     10     18.18     90.91
      |
 8    |*********                                          1     11      9.09    100.00
      |
      -----+----+----+----+----+----+----+-
           5   10   15   20   25   30   35

                     PERCENTAGE
```

```
PRINCE EDWARD ISLAND SUMMARY
S=2

PERCENTAGE BAR CHART

CMD   MAXIMUM DRAEGER                       FREQ  CUM.   PERCENT    CUM.
                                                  FREQ             PERCENT
       |
 3     |*****                                  1     1     9.09      9.09
       |
 4     |**************                         3     4    27.27     36.36
       |
 8     |***************************            6    10    54.55     90.91
       |
10     |*****                                  1    11     9.09    100.00
       |
       -----+----+----+----+----+--
           10   20   30   40   50

               PERCENTAGE
```

```
NOVA SCOTIA SUMMARY
GROUP1=1

VARIABLE   LABEL                          N         MEAN           STD ERROR
                                                                    OF MEAN

NIOSH                                    17    52.02941176        4.47449278
MAXNIOSH                                 17    58.82352941        4.91339353
AVDRAEG                                   0         .                 .
MAXDRAEG                                  0         .                 .
BN         % AVNIOSH GT 100              17     5.88235294        5.88235294
BBN        % MAXNIOSH GT 100             17     5.88235294        5.88235294
DE         % WITH D OR E                  0         .                 .
E          % WITH E                       0         .                 .

GROUP1=3 -------------------------------------------------------------------

NIOSH                                    83    75.92771084        3.45162119
MAXNIOSH                                 83    84.66265060        3.72048191
AVDRAEG                                  83     2.26554838        0.15511036
MAXDRAEG                                 83     4.51686747        0.28056248
BN         % AVNIOSH GT 100              83    18.07228916        4.24927724
BBN        % MAXNIOSH GT 100             83    27.71084337        4.94258930
DE         % WITH D OR E                 83    30.12048193        5.06639425
E          % WITH E                      83    27.71084337        4.94258930
```

```
NOVA SCOTIA SUMMARY
G=1

PERCENTAGE BAR CHART

CN   AVERAGE NIOSH                              FREQ   CUM.   PERCENT    CUM.
                                                       FREQ             PERCENT
     |
 2   |***********************************          6      6     35.29     35.29
     |
 3   |*****************************************    7     13     41.18     76.47
     |
 4   |************                                 2     15     11.76     88.24
     |
 5   |******                                       1     16      5.88     94.12
     |
 6   |******                                       1     17      5.88    100.00
     |
     -----+----+----+----+----+----+----+----+-
          5   10   15   20   25   30   35   40

                    PERCENTAGE
```

```
NOVA SCOTIA SUMMARY
G=2

PERCENTAGE BAR CHART

CN   AVERAGE NIDSH                                                  FREQ  CUM.   PERCENT    CUM.
                                                                          FREQ             PERCENT
       I
 2     I****************                                             10    10     12.05     12.05
       I
 3     I*********************                                        13    23     15.66     27.71
       I
 4     I*********************************************                28    51     33.73     61.45
       I
 5     I***************************                                  17    68     20.48     81.93
       I
 6     I****************                                             10    78     12.05     93.96
       I
 7     I**                                                            1    79      1.20     95.18
       I
 8     I**                                                            1    80      1.20     96.39
       I
 9     I*****                                                         3    83      3.61    100.00
       I
       ----+---+---+---+---+---+---+---+---+---+---+-
           3   6   9  12  15  18  21  24  27  30  33

                      PERCENTAGE
```

```
NOVA SCOTIA SUMMARY
G=1

PERCENTAGE BAR CHART

 CMM    MAXIMUM WIDTH                         FREQ   CUM.    PERCENT    CUM.
                                                     FREQ              PERCENT
        I
  2     I******                                  2      2     11.76     11.76
        I
  3     I*****************************          10     12     58.82     70.59
        I
  4     I*********                               3     15     17.65     88.24
        I
  5     I***                                     1     16      5.88     94.12
        I
  6     I***                                     1     17      5.88    100.00
        I
        -----+----+----+----+----+----
            10   20   30   40   50

              PERCENTAGE
```

```
NOVA SCOTIA SUMMARY
G=2

PERCENTAGE BAR CHART

CHN   MAXIMUM WIDTH                                        FREQ  CUM.  PERCENT    CUM.
                                                                 FREQ           PERCENT
      I
 2    I********                                              5     5     6.02     6.02
      I
 3    I*********************                                13    18    15.66    21.69
      I
 4    I*************************************                23    41    27.71    49.40
      I
 5    I*******************************                      19    60    22.89    72.29
      I
 6    I************************                             15    75    18.07    90.36
      I
 7    I*****                                                 3    78     3.61    93.98
      I
 8    I***                                                   2    80     2.41    96.39
      I
 9    I**                                                    1    81     1.20    97.59
      I
10    I***                                                   2    83     2.41   100.00
      I
      ----+---+---+---+---+---+---+---+---+-
          3   6   9  12  15  18  21  24  27

                 PERCENTAGE
```

```
NOVA SCOTIA SUMMARY
G=2

PERCENTAGE BAR CHART

CD      AVERAGE DRAEGER                      FREQ    CUM.    PERCENT      CUM.
                                                     FREQ               PERCENT
        I
 1      I************                            5      5       6.02      6.02
        I
 2      I*****************                       7     12       8.43     14.46
        I
 3      I**********************************     14     26      16.87     31.33
        I
 4      I**********************************     14     40      16.87     48.19
        I
 5      I**********************************     14     54      16.87     65.06
        I
 6      I***************************            11     65      13.25     78.31
        I
 7      I*****************                       7     72       8.43     86.75
        I
 8      I**********                              4     76       4.82     91.57
        I
 9      I*****                                   2     78       2.41     93.98
        I
10      I************                            5     83       6.02    100.00
        I
        ----+---+---+---+---+---+---+---+--
            2   4   6   8  10  12  14  16

                  PERCENTAGE
```

```
NOVA SCOTIA SUMMARY
G=2

PERCENTAGE BAR CHART

[illegible]ND   MAXIMUM DRAEGER                                   FREQ  CUM.   PERCENT    CUM.
                                                                        FREQ             PERCENT
            |
    1       |*****                                                  4      4      4.82      4.82
            |
    2       |*                                                      1      5      1.20      6.02
            |
    3       |*                                                      1      6      1.20      7.23
            |
    4       |***********                                            9     15     10.84     18.07
            |
    6       |*****************                                     14     29     16.87     34.94
            |
    8       |***********************************                   29     58     34.94     69.88
            |
   10       |******************************                        25     83     30.12    100.00
            |
            -----+----+----+----+----+----+----+
                 5   10   15   20   25   30   35

                         PERCENTAGE
```

```
NEW BRUNSWICK SUMMARY
GROUP1=1
                                             N          MEAN          STD ERROR
VARIABLE   LABEL                                                       OF MEAN

 IOSH                                       18      38.38888889      3.06960525
MAXNIOSH                                    18      43.11111111      3.76420090
AVDRAEG                                      0       .               .
MAXDRAEG                                     0       .               .
BN         % AVNIOSH GT 100                 18       0.00000000      0.00000000
BBN        % MAXNIOSH GT 100                18       0.00000000      0.00000000
DE         % WITH D OR E                     0       .               .
E          % WITH E                          0       .               .
-------------------------------------------------------------------------------
GROUP1=2 ----------------------------------------------------------------------

NIOSH                                        5      72.00000000     29.30870178
MAXNIOSH                                     5      84.00000000     27.67670501
AVDRAEG                                      5       3.77242424      0.69901452
MAXDRAEG                                     5       8.20000000      1.20000000
BN         % AVNIOSH GT 100                  5      20.00000000     20.00000000
BBN        % MAXNIOSH GT 100                 5      40.00000000     24.49489743
DE         % WITH D OR E                     5      80.00000000     20.00000000
E          % WITH E                          5      80.00000000     20.00000000
-------------------------------------------------------------------------------
GROUP1=3 ----------------------------------------------------------------------

NIOSH                                        3      55.33333333     33.19303809
MAXNIOSH                                     3      59.66666667     36.14938143
 VDRAEG                                      3       2.71296296      0.73294275
 AXDRAEG                                     3       5.00000000      1.00000000
BN         % AVNIOSH GT 100                  3      33.33333333     33.33333333
BBN        % MAXNIOSH GT 100                 3      33.33333333     33.33333333
DE         % WITH D OR E                     3      33.33333333     33.33333333
E          % WITH E                          3      33.33333333     33.33333333
-------------------------------------------------------------------------------
GROUP1=4 ----------------------------------------------------------------------

NIOSH                                       53      60.94339623      5.94333518
MAXNIOSH                                    53      73.13207547      7.18933443
AVDRAEG                                     53       2.73272162      0.30431456
MAXDRAEG                                    53       4.59811321      0.44600704
BN         % AVNIOSH GT 100                 53      16.98113208      5.20678987
BBN        % MAXNIOSH GT 100                53      20.75471698      5.62397584
DE         % WITH D OR E                    53      45.28301887      6.90282842
E          % WITH E                         53      32.07547170      6.47288915
-------------------------------------------------------------------------------
GROUP1=5 ----------------------------------------------------------------------

NIOSH                                       78      60.39743590      3.36449007
MAXNIOSH                                    78      71.70512821      3.89198605
AVDRAEG                                     78       2.63962230      0.20342144
MAXDRAEG                                    78       5.44615385      0.38010239
BN         % AVNIOSH GT 100                 78      10.25641026      3.45743519
 BBN       % MAXNIOSH GT 100                78      21.79487179      4.70488934
  E        % WITH D OR E                    78      52.56410256      5.69053141
E          % WITH E                         78      50.00000000      5.69802882
```

```
NEW BRUNSWICK SUMMARY
G=1.

PERCENTAGE BAR CHART

CN    AVERAGE MIDSH                                            FREQ   CUM.    PERCENT     CUM.
                                                                      FREQ              PERCENT
      |
 1    |***********                                                2      2     11.11     11.11
      |
 2    |********************************************               8     10     44.44     55.56
      |
 3    |*********************************                          6     16     33.33     88.89
      |
 4    |***********                                                2     18     11.11    100.00
      |
      -----+----+----+----+----+----+----+----+----
           5   10   15   20   25   30   35   40

                         PERCENTAGE
```

```
G=2

PERCENTAGE BAR CHART

 'N   AVERAGE NIOSH                                    FREQ  CUM.   PERCENT    CUM.
                                                             FREQ             PERCENT
      |
  1   |****************                                  16     16     11.51     11.51
      |
  2   |***********************************               35     51     25.18     36.69
      |
  3   |******************************                    30     81     21.58     58.27
      |
  4   |************************                          24    105     17.27     75.54
      |
  5   |***************                                   15    120     10.79     86.33
      |
  6   |**********                                        10    130      7.19     93.53
      |
  7   |*****                                              5    135      3.60     97.12
      |
  9   |***                                                3    138      2.16     99.28
      |
 10   |*                                                  1    139      0.72    100.00
      |
      ----+---+---+---+---+---+---+---+--
          3   6   9  12  15  18  21  24

               PERCENTAGE
```

```
NEW BRUNSWICK SUMMARY
G=1

PERCENTAGE BAR CHART

CMN   MAXIMUM NIOSH                 FREQ  CUM.    PERCENT    CUM.
                                          FREQ              PERCENT
      I
  1   I******                          2     2      11.11     11.11
      I
  2   I***********                     4     6      22.22     33.33
      I
  3   I*************************       9    15      50.00     83.33
      I
  4   I********                        3    18      16.67    100.00
      I
      -----+----+----+----+----+
          10   20   30   40   50

              PERCENTAGE
```

```
NEW BRUNSWICK SUMMARY
G=2

PERCENTAGE BAR CHART

CMN   MAXIMUM NIOSH                                   FREQ  CUM.   PERCENT    CUM.
                                                            FREQ             PERCENT
       |
  1    |*********                                        9     9      6.47      6.47
       |
  2    |***************************                     27    36     19.42     25.90
       |
  3    |********************************                32    68     23.02     48.92
       |
  4    |**********************                          22    90     15.83     64.75
       |
  5    |******************                              18   108     12.95     77.70
       |
  6    |***********                                     11   119      7.91     85.61
       |
  7    |**********                                      10   129      7.19     92.81
       |
  8    |****                                             4   133      2.88     95.68
       |
  9    |****                                             4   137      2.88     98.56
       |
 10    |**                                               2   139      1.44    100.00
       |
       ----+---+---+---+---+---+---+---
           3   6   9  12  15  18  21

                 PERCENTAGE
```

```
NEW BRUNSWICK SUMMARY
G=2

PERCENTAGE BAR CHART

ID    AVERAGE DRAEGER                                          FREQ  CUM.   PERCENT   CUM.
                                                                     FREQ            PERCENT
      |
 1    |*******                                                   5     5      3.60     3.60
      |
 2    |********************                                     14    19     10.07    13.67
      |
 3    |*********************************************            31    50     22.30    35.97
      |
 4    |************************                                 17    67     12.23    48.20
      |
 5    |*******************                                      13    80      9.35    57.55
      |
 6    |****************                                         11    91      7.91    65.47
      |
 7    |****************                                         11   102      7.91    73.38
      |
 8    |*************                                             9   111      6.47    79.86
      |
 9    |******                                                    4   115      2.88    82.73
      |
10    |***********************************                      24   139     17.27   100.00
      |
      ----+---+---+---+---+---+---+---+---+---+---+-
          2   4   6   8  10  12  14  16  18  20  22

                    PERCENTAGE
```

```
G=2

PERCENTAGE BAR CHART

CMD   MAXIMUM DRAEGER                      FREQ   CUM.     PERCENT     CUM.
                                                  FREQ              PERCENT
      I
 1    I*                                      4      4       2.88      2.88
      I
 2    I*                                      4      8       2.88      5.76
      I
 3    I***                                    8     16       5.76     11.51
      I
 4    I*********                             26     42      18.71     30.22
      I
 5    I*                                      3     45       2.16     32.37
      I
 6    I**                                     6     51       4.32     36.69
      I
 8    I********                              22     73      15.83     52.52
      I
 9    I                                       1     74       0.72     53.24
      I
10    I************************* 65    139      46.76    100.00
      I
      -----+----+----+----+---
          10   20   30   40

             PERCENTAGE
```

```
QUEBEC SUMMARY                 - 35 -
GROUP1=1

VARIABLE   LABEL                              N          MEAN          STD ERROR
                                                                        OF MEAN

NIOSH                                       132    26.19318182      1.86594330
MAXNIOSH                                    132    31.11363636      2.22210125
AVDBAEG                                       0     .                .
MAXDBAEG                                      0     .                .
BN         % AVNIOSH GT 100                 132     1.51515152      1.06727686
BBN        % MAXNIOSH GT 100                132     3.03030303      1.49770197
DE         % WITH D OR E                      0     .                .
E          % WITH E                           0     .                .

GROUP1=2 -----------------------------------------------------------------

NIOSH                                        37   129.86486486     15.68234849
MAXNIOSH                                     37   168.10810811     26.83180242
AVDBAEG                                      36     4.02703704      0.57271610
MAXDBAEG                                     36    10.63055556      1.62081608
BN         % AVNIOSH GT 100                  37    56.75675676      8.25689314
BBN        % MAXNIOSH GT 100                 37    62.16216216      8.08304434
DE         % WITH D OR E                     36    66.66666667      7.96819073
E          % WITH E                          36    63.88888889      8.11893513

GROUP1=3 -----------------------------------------------------------------

NIOSH                                       323    29.53095975      1.28852826
MAXNIOSH                                    323    34.32507740      1.51026355
AVDBAEG                                     305     1.37722799      0.10159043
MAXDBAEG                                    305     3.07278689      0.19684757
BN         % AVNIOSH GT 100                 323     1.85758514      0.75244506
BBN        % MAXNIOSH GT 100                323     2.78637771      0.91718221
DE         % WITH D OR E                    309    22.33009709      2.37299230
E          % WITH E                         309    21.35922330      2.33529241

GROUP1=4 -----------------------------------------------------------------

NIOSH                                       237    37.78270042      1.76597367
MAXNIOSH                                    237    43.31645570      2.02878020
AVDBAEG                                     231     1.86392074      0.13086348
MAXDBAEG                                    231     4.08658009      0.22549059
BN         % AVNIOSH GT 100                 237     3.79746835      1.24418319
BBN        % MAXNIOSH GT 100                237     5.06329114      1.42717600
DE         % WITH D OR E                    231    37.66233766      3.19495666
E          % WITH E                         231    34.19913420      3.12794740
```

```
QUEBEC SUMMARY
G= 1

PERCENTAGE BAR CHART

CN   AVERAGE NICSH               FREQ   CUM.    PERCENT     CUM.
                                        FREQ              PERCENT
       I
 1     I***********************   62     62     46.97      46.97
       I
 2     I******************        48    110     36.36      83.33
       I
 3     I*****                     12    122      9.09      92.42
       I
 4     I***                        7    129      5.30      97.73
       I
 5     I                           1    130      0.76      98.48
       I
 6     I                           1    131      0.76      99.24
       I
 7     I                           1    132      0.76     100.00
       I
       ----+----+----+----+---
          10   20   30   40

            PERCENTAGE
```

```
QUEBEC SUMMARY
G=2

PERCENTAGE BAR CHART

[illegible]N   AVERAGE NICSH                                             FREQ  CUM.   PERCENT    CUM.
                                                                             FREQ              PERCENT
              I
    1         I*******************************                        188   188     31.49      31.49
              I
    2         I*************************************                  223   411     37.35      68.84
              I
    3         I*****************                                      100   511     16.75      85.59
              I
    4         I******                                                  33   544      5.53      91.12
              I
    5         I***                                                     17   561      2.85      93.97
              I
    6         I**                                                      14   575      2.35      96.31
              I
    7         I**                                                      10   585      1.68      97.99
              I
    8         I*                                                        3   588      0.50      98.49
              I
    9         I                                                         1   589      0.17      98.66
              I
   10         I*                                                        8   597      1.34     100.00
              I
              -----+----+----+----+----+----+----+--
                   5   10   15   20   25   30   35

                         PERCENTAGE
```

```
QUEBEC SUMMARY
G=1

PERCENTAGE BAR CHART

                                                                FREQ  CUM.   PERCENT    CUM.
CMN   MAXIMUM NICSH                                                   FREQ            PERCENT
        I
   1    I****************************************                53     53   40.15     40.15
        I
   2    I************************************                    47    100   35.61     75.76
        I
   3    I***************                                         20    120   15.15     90.91
        I
   4    I****                                                     5    125    3.79     94.70
        I
   5    I**                                                       3    128    2.27     96.97
        I
   6    I**                                                       2    130    1.52     98.48
        I
   7    I**                                                       2    132    1.52    100.00
        I
        -----+----+----+----+----+----+----+----+
             5   10   15   20   25   30   35   40

                        PERCENTAGE
```

```
QUEBEC SUMMARY
G=2

PERCENTAGE BAR CHART

 .AN    MAXIMUM NICSH                                          FREQ   CUM.   PERCENT    CUM.
                                                                      FREQ             PERCENT
         I
  1      I*************************                             151    151    25.29     25.29
         I
  2      I**************************************                228    379    38.19     63.48
         I
  3      I******************                                    110    489    18.43     81.91
         I
  4      I*******                                                40    529     6.70     88.61
         I
  5      I****                                                   24    553     4.02     92.63
         I
  6      I**                                                     10    563     1.68     94.30
         I
  7      I**                                                     11    574     1.84     96.15
         I
  8      I**                                                      9    583     1.51     97.65
         I
  9      I*                                                       3    586     0.50     98.16
         I
 10      I**                                                     11    597     1.84    100.00
         I
         -----+----+----+----+----+----+----+---
              5   10   15   20   25   30   35

                   PERCENTAGE
```

```
QUEBEC SUMMARY
. G=2

PERCENTAGE BAR CHART

D    AVERAGE DRAEGER                                    FREQ   CUM.   PERCENT    CUM.
                                                               FREQ             PERCENT
     I
1    I**************************************            218    218    38.11     38.11
     I
2    I***************                                    86    304    15.03     53.15
     I
3    I***********                                        62    366    10.84     63.99
     I
4    I*******                                            39    405     6.82     70.80
     I
5    I*****                                              29    434     5.07     75.87
     I
6    I****                                               21    455     3.67     79.55
     I
7    I****                                               25    480     4.37     83.92
     I
8    I***                                                19    499     3.32     87.24
     I
9    I***                                                15    514     2.62     89.86
     I
10   I**********                                         58    572    10.14    100.00
     I
     -----+----+----+----+----+----+----+---
          5   10   15   20   25   30   35

                  PERCENTAGE
```

```
QUEBEC SUMMARY
. G=2

PERCENTAGE BAR CHART

IAD     MAXIMUM DEGREE                                  FREQ   CUM.    PERCENT      CUM.
                                                               FREQ               PERCENT
         I
  1      I********************************              136    136     23.78      23.78
         I
  2      I************                                   51    187      8.92      32.69
         I
  3      I***********                                    47    234      8.22      40.91
         I
  4      I****************                               69    303     12.06      52.97
         I
  6      I*****                                          21    324      3.67      56.64
         I
  8      I******************                             76    400     13.29      69.93
         I
 10      I****************************************      172    572     30.07     100.00
         I
         ----+---+---+---+---+---+---+---+---+---+
             3   6   9  12  15  18  21  24  27  30

                       PERCENTAGE
```

```
ONTARIO SUMMARY
GROUP1=1

VARIABLE   LABEL                          N         MEAN        STD ERROR
                                                                 OF MEAN

NIOSH                                   140    43.66785714    2.25296203
MAXNIOSH                                140    56.00714286    3.34126919
AVDRAEG                                   1     1.82000000        .
MAXDRAEG                                  1     4.00000000        .
BN         % AVNIOSH GT 100             140     5.00000000    1.84858491
BBN        % MAXNIOSH GT 100            140     9.28571429    2.46171686
DE         % WITH D OR E                  1     0.00000000        .
E          % WITH E                       1     0.00000000        .

GROUP1=2 ------------------------------------------------------------------

NIOSH                                    37   136.35135135   17.26123981
MAXNIOSH                                 37   154.86486486   19.03301076
AVDRAEG                                  36     4.13519921    0.44635678
MAXDRAEG                                 36     8.52222222    0.87165334
BN         % AVNIOSH GT 100              37    51.35135135    8.33028919
BBN        % MAXNIOSH GT 100             37    54.05405405    8.30589591
DE         % WITH D OR E                 35    71.42857143    7.74751635
E          % WITH E                      35    68.57142857    7.96149195

GROUP1=3 ------------------------------------------------------------------

NIOSH                                   147    61.58163265    3.12468819
MAXNIOSH                                147    73.01360544    3.95627705
AVDRAEG                                 145     1.80181264    0.12868843
MAXDRAEG                                145     3.97517241    0.25415047
BN         % AVNIOSH GT 100             147    12.92517007    2.77643827
BBN        % MAXNIOSH GT 100            147    17.00680272    3.10925366
DE         % WITH D OR E                145    31.03448276    3.85528962
E          % WITH E                     145    28.27586207    3.75263396

GROUP1=4 ------------------------------------------------------------------

NIOSH                                   541    64.15804067    1.56845763
MAXNIOSH                                541    77.73752311    2.06839374
AVDRAEG                                 537     2.21929944    0.07133447
MAXDRAEG                                537     4.85658324    0.15285298
BN         % AVNIOSH GT 100             541    14.41774492    1.51162356
BBN        % MAXNIOSH GT 100            541    22.18114603    1.78787654
DE         % WITH D OR E                538    43.12267658    2.13715139
E          % WITH E                     538    36.47583643    2.09956766
```

```
G= 1

PERCENTAGE BAR CHART

 N   AVERAGE NICSH                                      FREQ   CUM.   PERCENT    CUM.
                                                               FREQ            PERCENT
     I
 1   I******************                                 25     25    17.86     17.86
     I
 2   I************************************               51     76    36.43     54.29
     I
 3   I****************************                       39    115    27.86     82.14
     I
 4   I**********                                         14    129    10.00     92.14
     I
 5   I***                                                 4    133     2.86     95.00
     I
 6   I****                                                5    138     3.57     98.57
     I
 7   I*                                                   1    139     0.71     99.29
     I
10   I*                                                   1    140     0.71    100.00
     I
     -----+----+----+----+----+----+----+-
          5   10   15   20   25   30   35

               PERCENTAGE
```

```
G=2

PERCENTAGE BAR CHART

 N    AVERAGE NICSU                                  FREQ  CUM.   PERCENT    CUM.
                                                           FREQ             PERCENT
      |
 1    |******                                          31    31      4.28      4.28
      |
 2    |********************************               175   206     24.14     28.41
      |
 3    |************************************           196   402     27.03     55.45
      |
 4    |*************************                      135   537     18.62     74.07
      |
 5    |*************                                   72   609      9.93     84.00
      |
 6    |**********                                      53   662      7.31     91.31
      |
 7    |*****                                           28   690      3.86     95.17
      |
 8    |**                                              12   702      1.66     96.83
      |
 9    |*                                                6   708      0.83     97.66
      |
10    |***                                             17   725      2.34    100.00
      |
      ----+---+---+---+---+---+---+---+---+
          3   6   9  12  15  18  21  24  27

                   PERCENTAGE
```

```
ONTARIO SUMMARY
G=1

PERCENTAGE BAR CHART

CMN   MAXIMUM NICSH                                        FREQ  CUM.   PERCENT    CUM.
                                                                 FREQ              PERCENT
       I
  1    I******************                                   18    18    12.86     12.86
       I
  2    I*********************************************        45    63    32.14     45.00
       I
  3    I*******************************                      31    94    22.14     67.14
       I
  4    I***********************                              23   117    16.43     83.57
       I
  5    I**********                                           10   127     7.14     90.71
       I
  6    I*******                                               7   134     5.00     95.71
       I
  7    I**                                                    2   136     1.43     97.14
       I
  8    I*                                                     1   137     0.71     97.86
       I
 10    I***                                                   3   140     2.14    100.00
       I
       ----+---+---+---+---+---+---+---+---+---+---
           3   6   9  12  15  18  21  24  27  30

                  PERCENTAGE
```

```
ONTARIO SUMMARY
G=2

PERCENTAGE BAR CHART

 MN   MAXIMUM NIOSH                              FREQ   CUM.    PERCENT    CUM.
                                                        FREQ              PERCENT
      I
 1    I***                                         19     19      2.62      2.62
      I
 2    I*************************                  136    155     18.76     21.38
      I
 3    I******************************* 168    323     23.17     44.55
      I
 4    I**************************                 143    466     19.72     64.28
      I
 5    I*****************                           94    560     12.97     77.24
      I
 6    I***********                                 58    618      8.00     85.24
      I
 7    I*******                                     37    655      5.10     90.34
      I
 8    I*****                                       29    684      4.00     94.34
      I
 9    I**                                          11    695      1.52     95.86
      I
10    I******                                      30    725      4.14    100.00
      I
      ----+---+---+---+---+---+---+---
          3   6   9  12  15  18  21

                PERCENTAGE
```

```
G=2

PERCENTAGE BAR CHART

ID   AVERAGE DRAEGER                                FREQ    CUM.   PERCENT     CUM.
                                                            FREQ              PERCENT
      I
 1    I************************                       86      86     11.98      11.98
      I
 2    I*******************************               110     196     15.32      27.30
      I
 3    I*****************************                 103     299     14.35      41.64
      I
 4    I*************************                      90     389     12.53      54.18
      I
 5    I**************************                     92     481     12.81      66.99
      I
 6    I***************                                54     535      7.52      74.51
      I
 7    I*************                                  45     580      6.27      80.78
      I
 8    I*********                                      32     612      4.46      85.24
      I
 9    I******                                         22     634      3.06      88.30
      I
10    I***********************                        84     718     11.70     100.00
      I
      ----+---+---+---+---+---+---+---
          2   4   6   8  10  12  14

               PERCENTAGE
```

```
PERCENTAGE BAR CHART

 ND   MAXIMUM DEGREE                                FREQ  CUM.   PERCENT    CUM.
                                                          FREQ             PERCENT
       I
  1    I****                                          30    30      4.18      4.18
       I
  2    I*****                                         36    66      5.01      9.19
       I
  3    I********                                      55   121      7.66     16.85
       I
  4    I*************                                 90   211     12.53     29.39
       I
  6    I**********                                    70   281      9.75     39.14
       I
  8    I*********************                        154   435     21.45     60.58
       I
 10    I*************************************** 283   718     39.42    100.00
       I
       ----+----+----+----+----+----+----+----
           5   10   15   20   25   30   35

                    PERCENTAGE
```

```
MANITOBA SUMMARY
GROUP1=1

VARIABLE    LABEL                           N         MEAN          STD ERROR
                                                                     OF MEAN

NIOSH                                      22     34.65909091     5.06498744
MAXNIOSH                                   22     39.95454545     5.72662849
AVDBAEG                                     0          .              .
MAXDBAEG                                    0          .              .
BN          % AVNIOSH GT 100               22      4.54545455     4.54545455
BBN         % MAXNIOSH GT 100              22      4.54545455     4.54545455
DE          % WITH D OR E                   0          .              .
E           % WITH E                        0          .              .

GROUP1=3 ---------------------------------------------------------------------

NIOSH                                      13     39.19230769     6.10131828
MAXNIOSH                                   13     50.61538462     7.65316966
AVDBAEG                                    14      3.69128968     0.52006611
MAXDBAEG                                   14      6.72142857     0.89640176
BN          % AVNIOSH GT 100               13      0.00000000     0.00000000
BBN         % MAXNIOSH GT 100              13      0.00000000     0.00000000
DE          % WITH D OR E                  14     64.28571429    13.28943585
E           % WITH E                       14     57.14285714    13.72527033

GROUP1=4 ---------------------------------------------------------------------

NIOSH                                      94     40.55319149     2.79584934
MAXNIOSH                                   94     49.60638298     3.64317943
AVDBAEG                                    94      2.79340932     0.18834173
MAXDBAEG                                   94      5.22978723     0.29104624
BN          % AVNIOSH GT 100               94      3.19148936     1.82268658
BBN         % MAXNIOSH GT 100              94      8.51063830     2.89350936
DE          % WITH D OR E                  94     59.57446809     5.08681291
E           % WITH E                       94     46.80851064     5.17416571
```

```
MANITOBA SUMMARY
G=1

PERCENTAGE BAR CHART

CN   AVERAGE NIOSH                             FREQ  CUM.   PERCENT     CUM.
                                                     FREQ              PERCENT
     I
 1   I************************************       8      8    36.36      36.36
     I
 2   I***************************                6     14    27.27      63.64
     I
 3   I********************************           7     21    31.82      95.45
     I
 6   I*****                                      1     22     4.55     100.00
     I
     -----+----+----+----+----+----+----+-
          5   10   15   20   25   30   35

                   PERCENTAGE
```

```
MANITOBA SUMMARY
G=2

PERCENTAGE BAR CHART

CN   AVERAGE NICSH                                          FREQ   CUM.   PERCENT    CUM.
                                                                   FREQ             PERCENT
        I
 1      I**********************                               24     24     22.43     22.43
        I
 2      I**************************************               41     65     38.32     60.75
        I
 3      I**********************                               24     89     22.43     83.18
        I
 4      I*********                                            10     99      9.35     92.52
        I
 5      I*****                                                 5    104      4.67     97.20
        I
 7      I**                                                    2    106      1.87     99.07
        I
 9      I*                                                     1    107      0.93    100.00
        I
        -----+----+----+----+----+----+----+---
             5   10   15   20   25   30   35

                    PERCENTAGE
```

```
MANITOBA SUMMARY
G=1

PERCENTAGE BAR CHART

                                                    FREQ   CUM.   PERCENT    CUM.
CHN  MAXIMUM NIOSH                                         FREQ             PERCENT

     I                                                 7      7     31.82     31.82
 1   I******************************************
     I                                                 5     12     22.73     54.55
 2   I******************************
     I                                                 7     19     31.82     86.36
 3   I******************************************
     I                                                 2     21      9.09     95.45
 4   I************
     I                                                 1     22      4.55    100.00
 7   I******
     I
     ----+---+---+---+---+---+---+---+---+---+--
         3   6   9  12  15  18  21  24  27  30

                    PERCENTAGE
```

```
MANITOBA SUMMARY
G=2

PERCENTAGE BAR CHART

CNN   MAXIMUM MICSH                                         FREQ  CUM.   PERCENT    CUM.
                                                                  FREQ             PERCENT
        I
  1     I*************                                        14    14     13.08     13.08
        I
  2     I************************************                 39    53     36.45     49.53
        I
  3     I*************************                            27    80     25.23     74.77
        I
  4     I***********                                          12    92     11.21     85.98
        I
  5     I*******                                               7    99      6.54     92.52
        I
  6     I**                                                    2   101      1.87     94.39
        I
  7     I*                                                     1   102      0.93     95.33
        I
  8     I***                                                   3   105      2.80     98.13
        I
  9     I**                                                    2   107      1.87    100.00
        I
        -----+----+----+----+----+----+----+-
             5   10   15   20   25   30   35

                  PERCENTAGE
```

```
MANITOBA SUMMARY
G= 2

PERCENTAGE BAR CHART

  CD   AVERAGE CHARGES                               FREQ   CUM.   PERCENT      CUM.
                                                            FREQ             PERCENT
       I
   2   I*******************                            10     10      9.26      9.26
       I
   3   I*************************************          20     30     18.52     27.78
       I
   4   I*******************************                17     47     15.74     43.52
       I
   5   I*******************                            10     57      9.26     52.78
       I
   6   I*****************                               9     66      8.33     61.11
       I
   7   I***********                                     6     72      5.56     66.67
       I
   8   I***********                                     6     78      5.56     72.22
       I
   9   I*************                                   7     85      6.48     78.70
       I
  10   I*******************************************    23    108     21.30    100.00
       I
       ----+---+---+---+---+---+---+---+---+---+---
           2   4   6   8  10  12  14  16  18  20

                         PERCENTAGE
```

```
MANITOBA SUMMARY
G=2

PERCENTAGE BAR CHART

CMD   MAXIMUM DEGREES                    FREQ  CUM.   PERCENT    CUM.
                                               FREQ             PERCENT
        I
  2     I*                                  2     2      1.85      1.85
        I
  3     I**                                 4     6      3.70      5.56
        I
  4     I********                          17    23     15.74     21.30
        I
  6     I****                               8    31      7.41     28.70
        I
  8     I***********                       23    54     21.30     50.00
        I
 10     I*************************         54   108     50.00    100.00
        I
        ----+----+----+----+----+
           10   20   30   40   50

              PERCENTAGE
```

```
SASKATCHEWAN SUMMARY
GROUP1=1

VARIABLE   LABEL                          N          MEAN           STD ERROR
                                                                     OF MEAN

NIOSH                                     9     33.83333333      6.69680687
MAXNIOSH                                  9     42.55555556      7.54451808
AVDRAEG                                   0      .                .
MAXDRAEG                                  0      .                .
BN         % AVNIOSH GT 100               9      0.00000000      0.00000000
BBN        % MAXNIOSH GT 100              9      0.00000000      0.00000000
DE         % WITH D OR E                  0      .                .
E          % WITH E                       0      .                .

GROUP1=3 ---------------------------------------------------------------------

NIOSH                                     5     52.90000000     11.43394070
MAXNIOSH                                  5     57.40000000     11.65589979
AVDRAEG                                   5      2.01000000      0.41198301
MAXDRAEG                                  5      3.80000000      0.91651514
BN         % AVNIOSH GT 100               5      0.00000000      0.00000000
BBN        % MAXNIOSH GT 100              5      0.00000000      0.00000000
DE         % WITH D OR E                  5     20.00000000     20.00000000
E          % WITH E                       5     20.00000000     20.00000000

GROUP1=4 ---------------------------------------------------------------------

NIOSH                                    34     37.32352941      3.11176841
MAXNIOSH                                 34     42.97058824      3.60270380
AVDRAEG                                  34      2.64250000      0.25313509
MAXDRAEG                                 34      4.93823529      0.38603092
BN         % AVNIOSH GT 100              34      0.00000000      0.00000000
BBN        % MAXNIOSH GT 100             34      0.00000000      0.00000000
DE         % WITH D OR E                 33     78.78787879      7.22681213
E          % WITH E                      33     48.48484848      8.83477560
```

```
SASKATCHEWAN SUMMARY
G=1

PERCENTAGE BAR CHART

CN   AVERAGE NIOSH                                                FREQ   CUM.    PERCENT     CUM.
                                                                         FREQ              PERCENT
     |
 1   |*******************************************************        3      3     33.33      33.33
     |
 2   |*******************************************************        3      6     33.33      66.67
     |
 3   |*************************************                          2      8     22.22      88.89
     |
 4   |******************                                             1      9     11.11     100.00
     |
     ----+----+----+----+----+----+----+----+----+----+----+
         3    6    9   12   15   18   21   24   27   30   33

                        PERCENTAGE
```

```
SASKATCHEWAN SUMMARY
G=2

PERCENTAGE BAR CHART

CN     AVERAGE NIOSH                                    FREQ  CUM.   PERCENT     CUM.
                                                              FREQ             PERCENT
       |
 1     |***************                                   6      6     15.38     15.38
       |
 2     |*****************************************        16     22     41.03     56.41
       |
 3     |*******************************                  12     34     30.77     87.18
       |
 4     |**********                                        4     38     10.26     97.44
       |
 5     |***                                               1     39      2.56    100.00
       |
       -----+----+----+----+----+----+----+----+-
            5   10   15   20   25   30   35   40

                     PERCENTAGE
```

```
SASKATCHEWAN SUMMARY
G=1

PERCENTAGE BAR CHART

CMN   MAXIMUM NIOSH                                              FREQ  CUM.   PERCENT    CUM.
                                                                       FREQ              PERCENT
        I
  1     I************                                              1     1     11.11     11.11
        I
  2     I************************************************          4     5     44.44     55.56
        I
  3     I************                                              1     6     11.11     66.67
        I
  4     I************************************                      3     9     33.33    100.00
        I
        -----+----+----+----+----+----+----+----+----
             5   10   15   20   25   30   35   40

                        PERCENTAGE
```

```
G=2

PERCENTAGE BAR CHART

CNN   MAXIMUM NIOSH               FREQ  CUM.   PERCENT    CUM.
                                        FREQ            PERCENT
      |
  1   |***                          2      2     5.13     5.13
      |
  2   |************************    19     21    48.72    53.85
      |
  3   |**********                   8     29    20.51    74.36
      |
  4   |********                     6     35    15.38    89.74
      |
  5   |*****                        4     39    10.26   100.00
      |
      ----+----+----+----+----
         10   20   30   40

              PERCENTAGE
```

```
G=2

PERCENTAGE BAR CHART

CD   AVERAGE DRAEGER                                       FREQ  CUM.   PERCENT    CUM.
                                                                 FREQ            PERCENT
     |
 1   |***************                                         3     3     7.69      7.69
     |
 2   |**********                                              2     5     5.13     12.82
     |
 3   |*********************                                   4     9    10.26     23.08
     |
 4   |**************************                              5    14    12.82     35.90
     |
 5   |*****************************************               8    22    20.51     56.41
     |
 6   |*********************                                   4    26    10.26     66.67
     |
 7   |*********************                                   4    30    10.26     76.92
     |
 8   |**********                                              2    32     5.13     82.05
     |
 9   |*****                                                   1    33     2.56     84.62
     |
10   |*******************************                         6    39    15.38    100.00
     |
     ----+---+---+---+---+---+---+---+---+---+-
         2   4   6   8  10  12  14  16  18  20

                  PERCENTAGE
```

```
SASKATCHEWAN SUMMARY
G=2

PERCENTAGE BAR CHART

CMD   MAXIMUM DRAEGER                                    FREQ  CUM.   PERCENT    CUM.
                                                               FREQ              PERCEN
       |
 1     |*****                                               2     2      5.13      5.1
       |
 3     |***                                                 1     3      2.56      7.6
       |
 4     |********                                            3     6      7.69     15.3
       |
 6     |********                                            3     9      7.69     23.0
       |
 8     |*********************************                  13    22     33.33     56.4
       |
10     |*******************************************        17    39     43.59    100.0
       |
       -----+----+----+----+----+----+----+----+----
            5   10   15   20   25   30   35   40

                        PERCENTAGE
```

```
ALBERTA SUMMARY
GROUP1=1

VARIABLE   LABEL                        N       MEAN          STD ERROR
                                                               OF MEAN

NIOSH                                   7    29.28571429    6.10996176
MAXNIOSH                                7    35.71428571    5.92699348
AVDBAEG                                 0         .              .
MAXDBAEG                                0         .              .
BN         % AVNIOSE GT 100             7     0.00000000    0.00000000
BBN        % MAXNIOSH GT 100            7     0.00000000    0.00000000
DE         % WITH D OR E                0         .              .
E          % WITH E                     0         .              .

GROUP1=3 ----------------------------------------------------------------

NIOSH                                  12    29.95833333    4.59926638
MAXNIOSH                               12    44.75000000   10.19441692
AVDBAEG                                12     1.48083333    0.32945553
MAXDBAEG                               12     2.70000000    0.47752519
BN         % AVNIOSH GT 100            12     0.00000000    0.00000000
BBN        % MAXNIOSH GT 100           12     8.33333333    8.33333333
DE         % WITH D OR E               12    16.66666667   11.23666437
E          % WITH E                    12     8.33333333    8.33333333

GROUP1=4 ----------------------------------------------------------------

NIOSH                                  24    62.72916667   12.24293567
MAXNIOSH                               24    75.54166667   12.88634531
AVDBAEG                                25     2.67052222    0.29834487
MAXDBAEG                               25     4.54400000    0.49602016
BN         % AVNIOSE GT 100            24     8.33333333    5.76303396
BBN        % MAXNIOSH GT 100           24    20.83333333    8.46811297
DE         % WITH D OR E               25    52.00000000   10.19803903
E          % WITH E                    25    36.00000000    9.79795897
```

```
ALBERTA SUMMARY
G=1

PERCENTAGE BAR CHART

CN    AVERAGE NIOSH                                        FREQ   CUM.   PERCENT     CUM.
                                                                  FREQ              PERCENT
       I
 1     I*****************************                         2      2     28.57      28.57
       I
 2     I*******************************************           3      5     42.86      71.43
       I
 3     I*****************************                         2      7     28.57     100.00
       I
       -----+----+----+----+----+----+----+----+--
            5   10   15   20   25   30   35   40

                     PERCENTAGE
```

```
PERCENTAGE BAR CHART

CN     AVERAGE NIOSH                             FREQ  CUM.  PERCENT      CUM.
                                                       FREQ            PERCENT
       |
 1     |*****************                           6     6    16.67     16.67
       |
 2     |************************************       13    19    36.11     52.78
       |
 3     |**********************                      8    27    22.22     75.00
       |
 4     |***********                                 4    31    11.11     86.11
       |
 5     |********                                    3    34     8.33     94.44
       |
 8     |***                                         1    35     2.78     97.22
       |
10     |***                                         1    36     2.78    100.00
       |
       -----+----+----+----+----+----+----+-
            5   10   15   20   25   30   35

                     PERCENTAGE
```

```
ALBERTA SUMMARY
G=1

PERCENTAGE BAR CHART

CAN   MAXIMUM NIOSH                         FREQ   CUM.   PERCENT     CUM.
                                                   FREQ             PERCENT
         |
  1      |*******                              1      1     14.29      14.29
         |
  2      |*****************************        4      5     57.14      71.43
         |
  3      |**************                       2      7     28.57     100.00
         |
         ----+----+----+----+----+----
            10   20   30   40   50

                  PERCENTAGE
```

```
ALBERTA SUMMARY
G=2

PERCENTAGE BAR CHART

 NN   MAXIMUM NIOSH                               FREQ  CUM.   PERCENT    CUM.
                                                        FREQ            PERCENT
      I
  1   I***************                               4     4    11.11    11.11
      I
  2   I*************************************        10    14    27.78    38.89
      I
  3   I*************************************        10    24    27.78    66.67
      I
  4   I***********                                   3    27     8.33    75.00
      I
  5   I***********                                   3    30     8.33    83.33
      I
  6   I****                                          1    31     2.78    86.11
      I
  7   I*******                                       2    33     5.56    91.67
      I
  8   I*******                                       2    35     5.56    97.22
      I
 10   I****                                          1    36     2.78   100.00
      I
      ----+---+---+---+---+---+---+---+---+-
          3   6   9  12  15  18  21  24  27

                 PERCENTAGE
```

```
ALBERTA SUMMARY
G=2

PERCENTAGE BAR CHART

ID    AVERAGE CHARGES                          FREQ  CUM.   PERCENT     CUM.
                                                     FREQ             PERCENT
      |
 1    |****************                            3     3      8.11      8.11
      |
 2    |***********                                 2     5      5.41     13.51
      |
 3    |********************************            6    11     16.22     29.73
      |
 4    |*************************************       7    18     18.92     48.65
      |
 5    |*************************************       7    25     18.92     67.57
      |
 6    |****************                            3    28      8.11     75.68
      |
 7    |*********************                       4    32     10.81     86.49
      |
 8    |*****                                       1    33      2.70     89.19
      |
 9    |*****                                       1    34      2.70     91.89
      |
10    |****************                            3    37      8.11    100.00
      |
      ----+---+---+---+---+---+---+---+---+--
          2   4   6   8  10  12  14  16  18

                   PERCENTAGE
```

```
ALBERTA SUMMARY
G=2

PERCENTAGE BAR CHART

CODE   MAXIMUM DRAEGER                                          FREQ  CUM.   PERCENT   CUM.
                                                                      FREQ             PERCENT
       I
  1    I*****                                                     2     2      5.41      5.41
       I
  2    I***                                                       1     3      2.70      8.11
       I
  3    I***                                                       1     4      2.70     10.81
       I
  4    I***********                                               4     8     10.81     21.62
       I
  6    I***********************************                      13    21     35.14     56.76
       I
  8    I*******************                                       7    28     18.92     75.68
       I
 10    I************************                                  9    37     24.32    100.00
       I
       ----+----+----+----+----+----+----+
           5   10   15   20   25   30   35

                   PERCENTAGE
```

```
BRITISH COLUMBIA SUMMARY
GROUP1=1
                                            N         MEAN           STD ERROR
VARIABLE    LABEL                                                     OF MEAN

                                           27     30.46296296      3.49398404
NIOSH                                      27     40.14814815      6.25473125
MAXNIOSH                                    0          .                .
AVDBAEG                                     0          .                .
MAXDBAEG                                   27      0.00000000      0.00000000
BN          % AVNIOSH GT 100               27      3.70370370      3.70370370
BBN         % MAXNIOSH GT 100               0          .                .
DE          % WITH D OR E                   0          .                .
E           % WITH E
--------------------------------------------------------------------------------
GROUP1=2 ----------------------------------------------------------------------
                                           14     64.28571429      8.43294727
NIOSH                                      14     77.85714286     11.05324632
MAXNIOSH                                   14      2.52306638      0.41687448
AVDBAEG                                    14      5.24285714      1.04895103
MAXDBAEG                                   14     14.28571429      9.70523172
BN          % AVNIOSH GT 100               14     28.57142857     12.52940028
BBN         % MAXNIOSH GT 100              14     42.85714286     13.72527033
DE          % WITH D OR E                  14     42.85714286     13.72527033
E           % WITH E
--------------------------------------------------------------------------------
GROUP1=3 ----------------------------------------------------------------------
                                           81     35.63580247      2.02015333
NIOSH                                      81     42.39506173      2.64777329
MAXNIOSH                                   81      3.07216268      0.18734196
AVDBAEG                                    81      5.22839506      0.26658699
MAXDBAEG                                   81      0.00000000      0.00000000
BN          % AVNIOSH GT 100               81      1.23456790      1.23456790
BBN         % MAXNIOSH GT 100              81     53.08641975      5.57950940
DE          % WITH D OR E                  81     51.85185185      5.58633449
E           % WITH E
--------------------------------------------------------------------------------
GROUP1=4 ----------------------------------------------------------------------
                                           46     37.44565217      2.45363913
NIOSH                                      46     43.41304348      2.96380355
MAXNIOSH                                   48      3.24119213      0.23006193
AVDBAEG                                    48      5.44166667      0.31983530
MAXDBAEG                                   46      0.00000000      0.00000000
BN          % AVNIOSH GT 100               46      0.00000000      0.00000000
BBN         % MAXNIOSH GT 100              48     58.33333333      7.19124106
DE          % WITH D OR E                  48     58.33333333      7.19124106
E           % WITH E
```

```
G=1

PERCENTAGE BAR CHART

   N   AVERAGE NIOSH                                                  FREQ  CUM.   PERCENT    CUM.
                                                                            FREQ             PERCENT
        I
  1     I*********************************                               9     9     33.33     33.33
        I
  2     I********************************************                   12    21     44.44     77.78
        I
  3     I***********                                                     3    24     11.11     88.89
        I
  4     I*******                                                         2    26      7.41     96.30
        I
  5     I****                                                            1    27      3.70    100.00
        I
        -----+----+----+----+----+----+----+----+----
             5   10   15   20   25   30   35   40

                      PERCENTAGE
```

```
BRITISH COLUMBIA SUMMARY
G=2

PERCENTAGE BAR CHART
                                                     FREQ   CUM.   PERCENT    CUM.
CM    AVERAGE NIOSH                                         FREQ              PERCENT

      |                                                20     20     14.18     14.18
1     |**************
      |                                                64     84     45.39     59.57
2     |*********************************************
      |                                                35    119     24.82     84.40
3     |*************************
      |                                                16    135     11.35     95.74
4     |***********
      |                                                 4    139      2.84     98.5
5     |***
      |                                                 2    141      1.42     100.0
6     |*
      |
      -----+----+----+----+----+----+----+----+----+
           5   10   15   20   25   30   35   40   45

                    PERCENTAGE
```

```
BRITISH COLUMBIA SUMMARY
G=1

PERCENTAGE BAR CHART

 MN   MAXIMUM NIOSH                                              FREQ  CUM.   PERCENT    CUM.
                                                                       FREQ             PERCENT
      I
  1   I*******************                                          5     5     18.52    18.52
      I
  2   I*****************************************                   11    16     40.74    59.26
      I
  3   I******************************                               8    24     29.63    88.89
      I
  4   I*******                                                      2    26      7.41    96.30
      I
  9   I****                                                         1    27      3.70   100.00
      I
      ----+----+----+----+----+----+----+----+-
          5   10   15   20   25   30   35   40

                     PERCENTAGE
```

```
G=2

PERCENTAGE BAR CHART

 MN   MAXIMUM NIOSH                                        FREQ  CUM.   PERCENT    CUM.
                                                                 FREQ            PERCENT
      I
  1   I***********                                           16    16     11.35    11.35
      I
  2   I**************************************                53    69     37.59    48.94
      I
  3   I****************************                          40   109     28.37    77.30
      I
  4   I**************                                        20   129     14.18    91.49
      I
  5   I*****                                                  7   136      4.96    96.45
      I
  6   I*                                                      2   138      1.42    97.87
      I
  7   I*                                                      1   139      0.71    96.58
      I
  8   I*                                                      2   141      1.42   100.00
      I
      -----+----+----+----+----+----+----+---
           5   10   15   20   25   30   35

                    PERCENTAGE
```

```
BRITISH COLUMBIA SUMMARY
G=2

PERCENTAGE BAR CHART

                                                                 FREQ  CUM.   PERCENT    CUM.
 D   AVERAGE DRAEGER                                                   FREQ             PERCENT

      I
 1    I*******                                                     5     5      3.50      3.50
      I
 2    I*****************                                          12    17      8.39     11.89
      I
 3    I***********                                                 8    25      5.59     17.48
      I
 4    I**********************                                     16    41     11.19     28.67
      I
 5    I*************************                                  18    59     12.59     41.26
      I
 6    I*****************                                          12    71      8.39     49.65
      I
 7    I*************************                                  18    89     12.59     62.24
      I
 8    I*********************                                      15   104     10.49     72.73
      I
 9    I*****************                                          12   116      8.39     81.12
      I
10    I**************************************                     27   143     18.88    100.00
      I
      ----+---+---+---+---+---+---+---+---+--
          2   4   6   8  10  12  14  16  18

                 PERCENTAGE
```

```
BRITISH COLUMBIA SUMMARY
G=2

PERCENTAGE BAR CHART

CMD   MAXIMUM DRAEGER                  FREQ  CUM.   PERCENT    CUM.
                                             FREQ              PERCENT
          |
  1       |**                             5      5      3.50      3.50
          |
  2       |*                              2      7      1.40      4.90
          |
  3       |*                              4     11      2.80      7.69
          |
  4       |***                            9     20      6.25     13.99
          |
  6       |*****                         15     35     10.49     24.48
          |
  8       |***********                   31     66     21.68     46.15
          |
 10       |*************************** 77    143     53.85    100.00
          |
          -----+----+----+----+----+--
              10   20   30   40   50

                  PERCENTAGE
```

```
CANADIAN SUMMARY
GROUP1=1

VARIABLE    LABEL                          N        MEAN          STD ERROR
                                                                   OF MEAN

NIOSH                                    383    35.50000000     1.23000598
MAXNIOSH                                 383    43.69190601     1.67850945
AVDRAEG                                    1     1.82000000          .
MAXDRAEG                                   1     4.00000000          .
BN          % AVNIOSH GT 100             383     2.87206266     0.85454976
BBN         % MAXNIOSH GT 100            383     5.22193211     1.13825051
DE          % WITH D OR E                  1     0.00000000          .
E           % WITH E                       1     0.00000000          .

GROUP1=2 ---------------------------------------------------------------

NIOSH                                     93   119.46236559     9.80777805
MAXNIOSH                                  93   144.73118280    13.60687561
AVDRAEG                                   91     3.82445665     0.29945029
MAXDRAEG                                  91     8.83406593     0.76545568
BN          % AVNIOSH GT 100              93    46.23655914     5.19807292
BBN         % MAXNIOSH GT 100             93    52.68817204     5.20532099
DE          % WITH D OR E                 90    65.55555556     5.03696972
E           % WITH E                      90    63.33333333     5.10807053

GROUP1=3 ---------------------------------------------------------------

NIOSH                                    690    43.93913043     1.25184363
MAXNIOSH                                 690    51.35942029     1.48676729
AVDRAEG                                  671     1.86157349     0.06764128
MAXDRAEG                                 671     3.85305514     0.12432250
BN          % AVNIOSH GT 100             690     6.23188406     0.92093222
BBN         % MAXNIOSH GT 100            690     9.13043478     1.09735044
DE          % WITH D OR E                675    29.92592593     1.76389421
E           % WITH E                     675    28.14814815     1.73226348

GROUP1=4 ---------------------------------------------------------------

NIOSH                                   1063    53.82267168     1.09869308
MAXNIOSH                                1063    64.34242709     1.38537207
AVDRAEG                                 1056     2.33252896     0.05570281
MAXDRAEG                                1056     4.79232955     0.10265989
BN          % AVNIOSH GT 100            1063     9.87770461     0.91554961
BBN         % MAXNIOSH GT 100           1063    15.14581373     1.10007092
DE          % WITH D OR E               1056    46.49621212     1.53558840
E           % WITH E                    1056    40.15151515     1.50921572

GROUP1=5 ---------------------------------------------------------------

NIOSH                                     78    60.39743590     3.36449007
MAXNIOSH                                  78    71.70512821     3.89198605
AVDRAEG                                   78     2.63862230     0.20342144
MAXDRAEG                                  78     5.44615385     0.38010239
BN          % AVNIOSH GT 100              78    10.25641026     3.45743519
BBN         % MAXNIOSH GT 100             78    21.79487179     4.70468934
DE          % WITH D OR E                 78    52.56410256     5.69053141
E           % WITH E                      78    50.00000000     5.69802882
```

```
CANADIAN SUMMARY
G=1

PERCENTAGE BAR CHART

 N     AVERAGE NIOSH                                   FREQ   CUM.   PERCENT    CUM.
                                                              FREQ             PERCENT
       |
  1    |******************************                  113    113    29.50     29.50
       |
  2    |*************************************           143    256    37.34     66.84
       |
  3    |*********************                            81    337    21.15     87.99
       |
  4    |*******                                          28    365     7.31     95.30
       |
  5    |**                                                7    372     1.83     97.13
       |
  6    |**                                                8    380     2.09     99.22
       |
  7    |*                                                 2    382     0.52     99.74
       |
 10    |                                                  1    383     0.26    100.00
       |
       -----+----+----+----+----+----+----+--
            5   10   15   20   25   30   35

                 PERCENTAGE
```

```
CANADIAN SUMMARY
G=2

PERCENTAGE BAR CHART

 CN   AVERAGE NIOSH                                          FREQ      CUM.    PERCENT      CUM.
                                                                       FREQ              PERCENT
          I
  1       I*********************                              297       297      15.44      15.44
          I
  2       I*****************************************          589       886      30.61      46.05
          I
  3       I******************************                     435      1321      22.61      68.66
          I
  4       I*******************                                267      1588      13.88      82.54
          I
  5       I*********                                          137      1725       7.12      89.66
          I
  6       I******                                              92      1817       4.78      94.44
          I
  7       I***                                                 46      1863       2.39      96.83
          I
  8       I*                                                   19      1882       0.99      97.82
          I
  9       I*                                                   15      1897       0.78      98.60
          I
 10       I**                                                  27      1924       1.40     100.00
          I
          ----+---+---+---+---+---+---+---+---+---+-
              3   6   9  12  15  18  21  24  27  30

                          PERCENTAGE
```

```
CANADIAN SUMMARY
G=1

PERCENTAGE BAR CHART

  MN    MAXIMUM NIOSH                                                  FREQ   CUM.    PERCENT     CUM.
                                                                              FREQ              PERCENT
         I
   1     I*******************************                                89     89     23.24     23.24
         I
   2     I******************************************** 126                     215     32.90     56.14
         I
   3     I********************************                               92    307     24.02     80.16
         I
   4     I***************                                                42    349     10.97     91.1
         I
   5     I*****                                                          14    363      3.66     94.7
         I
   6     I***                                                            10    373      2.61     97.3
         I
   7     I**                                                              5    378      1.31     98.6
         I
   8     I                                                                1    379      0.26     98.9
         I
   9     I                                                                1    380      0.26     99.2
         I
  10     I*                                                               3    383      0.78    100.0
         I
         ----+---+---+---+---+---+---+---+---+---+---+
             3   6   9  12  15  18  21  24  27  30  33

                     PERCENTAGE
```

```
CANADIAN SUMMARY
G=2

PERCENTAGE BAR CHART

 CHN   MAXIMUM NIOSH                                    FREQ     CUM.   PERCENT      CUM.
                                                                 FREQ             PERCENT
       |
   1   |***************                                  220      220     11.43     11.43
       |
   2   |************************************             527      747     27.39     38.83
       |
   3   |*****************************                    424     1171     22.04     60.86
       |
   4   |*******************                              276     1447     14.35     75.21
       |
   5   |*************                                    187     1634      9.72     84.93
       |
   6   |*******                                          101     1735      5.25     90.18
       |
   7   |*****                                             68     1803      3.53     93.71
       |
   8   |****                                              52     1855      2.70     96.41
       |
   9   |**                                                23     1878      1.20     97.61
       |
  10   |***                                               46     1924      2.39    100.00
       |
       ----+---+---+---+---+---+---+---+---+-
           3   6   9  12  15  18  21  24  27

                    PERCENTAGE
```

```
CANADIAN SUMMARY
G=2

PERCENTAGE BAR CHART
                                                        FREQ    CUM.    PERCENT     CUM.
CD   AVERAGE CHARGER                                            FREQ              PERCENT

      I
 1    I*********************************** 328     328     17.30       17.30
      I
 2    I**************************          248     576     13.08       30.38
      I
 3    I***************************         255     831     13.45       43.83
      I
 4    I**********************              213    1044     11.23       55.06
      I
 5    I********************                194    1238     10.23       65.30
      I
 6    I**************                      131    1369      6.91       72.20
      I
 7    I*************                       124    1493      6.54       78.74
      I
 8    I**********                           95    1588      5.01       83.76
      I
 9    I*******                              68    1656      3.59       87.34
      I
10    I*************************           240    1896     12.66      100.00
      I
      ----+---+---+---+---+---+---+---+---
          2   4   6   8  10  12  14  16

                  PERCENTAGE
```

```
CANADIAN SUMMARY
G=2

PERCENTAGE BAR CHART
                                                   FREQ      CUM.   PERCENT     CUM.
 MD   MAXIMUM DANGER                                         FREQ              PERCENT

      I                                             184       184      9.70       9.70
  1   I**********
      I                                              97       281      5.12      14.82
  2   I*****
      I                                             123       404      6.49      21.31
  3   I******
      I                                             231       635     12.18      33.49
  4   I************
      I                                               3       638      0.16      33.65
  5   I
      I                                             152       790      8.02      41.67
  6   I********
      I                                             371      1161     19.57      61.23
  8   I********************
      I                                               1      1162      0.05      61.29
  9   I
      I                                             734      1896     38.71     100.00
 10   I***************************************
      I
       ----+----+----+----+----+----+----+----
           5   10   15   20   25   30   35

                   PERCENTAGE
```

Section 2. Relating Formaldehyde Levels to Other Factors

2.1 Introduction

This section considers the problems of relating levels of formaldehyde (NIOSH, Draeger readings) to other factors measured on each home. The approach used is to divide the analysis into sections as follows.

(i) Niosh versus all other factors including Draeger values,
(ii) Draeger readings versus all other factors.

In a preliminary analysis, it was discovered that the forms of the relationships in (i) and (ii) were dependent on the construction of the house. For this reason, the houses were divided into three classes.

ppb ✓

Class	Niosh Average	Draeger Average
UFFI between brick and sheathing	43.2(560)	1.45
UFFI in stud space	→ 60.7(1086)	2.64
UFFI between brick walls	→ 50.3(162)	2.87

The differences amongst these averages cannot necessarily be explained by the construction type as there is confounding due to location (for example, there are almost no brick homes recorded in the Maritimes). In the subsequent sections, each class of home is studied separately.

The basic method for studying the relationship between a dependent variable (such as average NIOSH level) and a set of explanatory variables (such as wall cavity measurements) is to use multiple regresion. The model for this analysis takes the form

$$y = \alpha + \beta_1 X_1 + \ldots + \beta_k X_k + e$$

where y: the dependent variable,

$X_1, \ldots, X_k$: explanatory variables,

$\beta_1, \ldots, \beta_k$: regression coefficients,

e: residual variation not accounted for by the explanatory variables.

The regression coefficient β_i measures the strength of the relationship (on a linear scale) between y and X_i when all other explanatory variables are held fixed. The average value of y will change by β_i units if X_i changes by 1.

The residual variation e can be expected to be quite large in the analyses because of the large measurement errors in the NIOSH and Draeger readings. These errors cannot be attributed to any of the explanatory variables. This large residual variation means that the models fitted to the data will not be useful for prediction. They can, however, point to explanatory variables which are important and unimportant in determining the levels of the dependent variables.

One word of caution is necessary about the interpretation of the results from this study. In the study, there was no control over the variation of the explanatory factors. For this reason, some of these factors are highly correlated and it is not possible to untangle the relationships between these variables and the dependent variable.

2.2 Homes with UFFI Between Brick and Sheathing

(i) NIOSH versus all.

To analyze the variation among the average NIOSH values in this class of home, a multiple regression model was fit to the data. This model included the variables given in the left hand column of table 2.1. Since there was only one home from the Maritimes in the 209 homes in this group (having complete information), homes from the Maritimes were included in the subsequent analysis and a separate analysis was not carried out in all cases (there was no effect of inclusion of the Maritime results in this analysis).

```
                          SUM OF           MEAN
SOURCE      DF           SQUARES         SQUARE        F VALUE       PROB>F

MODEL       12            123976      10331.317          7.928       0.0001
ERROR      197            256709       1303.091
C TOTAL    209            380685

     ROOT MSE          36.098354       R-SQUARE         0.3257
     DEP MEAN          49.033333       ADJ R-SQ         0.2846
     C.V.               73.62003


                       PARAMETER       STANDARD    T FOR HO:
VARIABLE    DF          ESTIMATE          ERROR  PARAMETER=0    PROB > |T|

INTERCEP     1         -1.919770      48.098273       -0.040        0.9682
INTEMP       1          3.510719       1.631816        2.151        0.0327
EXTEMP       1          0.256533       0.741480        0.346        0.7297
INHUMID      1         -1.090401       0.267275       -4.080        0.0001
MOISTBAR     1          9.750140       5.554342        1.755        0.0807
EXHUMID      1          0.115372       0.184066        0.627        0.5315
PERCENT      1          0.024634       0.108222        0.228        0.8202
UAGE         1         -0.219145       0.239900       -0.913        0.3621
AVDRAEG      1          9.335836       1.432890        6.515        0.0001
WALLCOND     1         -7.224034       4.849681       -1.490        0.1379
DAMAGE       1          4.586040       7.029470        0.652        0.5149
WM           1          0.799337       1.354247        0.590        0.5557
VAP          1          0.947497       1.520059        0.623        0.5338
```

Table 2.1

See Appendix 2 for interpretation

The significant factors related to the NIOSH values are internal temperature, internal humidity, and average Draeger level. In the subsequent analysis the factor water vapour was also included because it had a significant effect in a preliminary analysis.

It is perhaps more interesting to study which factors did not seem to play an important role in the variation of NIOSH values. These include all the weather factors (except internal humidity) and all factors measured on the house type (except the structure).

The next model fitted included the variables on the left hand side of table 2.2.

```
                        SUM OF          MEAN
SOURCE      DF         SQUARES        SQUARE        F VALUE       PROB>F

MODEL        3          181167     60389.040         61.635       0.0001
ERROR      491          481076       979.788
C TOTAL    494          662243

     ROOT MSE        31.301562      R-SQUARE         0.2736
     DEP MEAN        43.245455      ADJ R-SQ         0.2691
     C.V.             72.38116

                     PARAMETER      STANDARD     T FOR H0:
VARIABLE    DF        ESTIMATE         ERROR   PARAMETER=0    PROB > |T|

INTERCEP     1       68.268703     10.291036         6.634        0.0001
AVDRAEG      1        8.088757      0.892080         9.067        0.0001
INHUMID      1       -0.905430      0.144135        -6.282        0.0001
VAP          1        2.994056      0.603678         4.960        0.0001
```

Table 2.2

The number of homes in the analysis has increased substantially (290 to 494) and there has only been a small decrease in the proportion of the variation explained by the model (33% to 28%). All factors in this analysis had a significant effect.

Factor	95% Confidence Interval for Coefficient
Average Draeger	8.1 ±1.8
Internal Humidity	-.91± .28
Average Vapour Level	3.0 ±1.2

Other models were also investigated and because of the relationships between the explanatory variables it was possible to find models in which different factors have significant effects.

To investigate the possibility of using the above model to predict the NIOSH values, the model

$$\underset{\text{NIOSH}}{\text{Predicted}} = 68.3 + 8.1\ \text{Avdraeg} - 0.91\ \text{Inhumid} + 3.0\ \text{Vap}$$

was used to predict the actual NIOSH values in this class. The NIOSH values were grouped into classes of width 10 ppb (i.e. 0-10, 10-20,...,≥90), and the average predicted value was compared to the actual average. Figure 2.1 shows the results of this exercise. The solid line indicates perfect prediction. It is clear that this model overpredicts low NIOSH values and underpredicts high values and is hence not useful as a predictor. This behaviour suggests that some important unknown factor has been left out of the analysis.

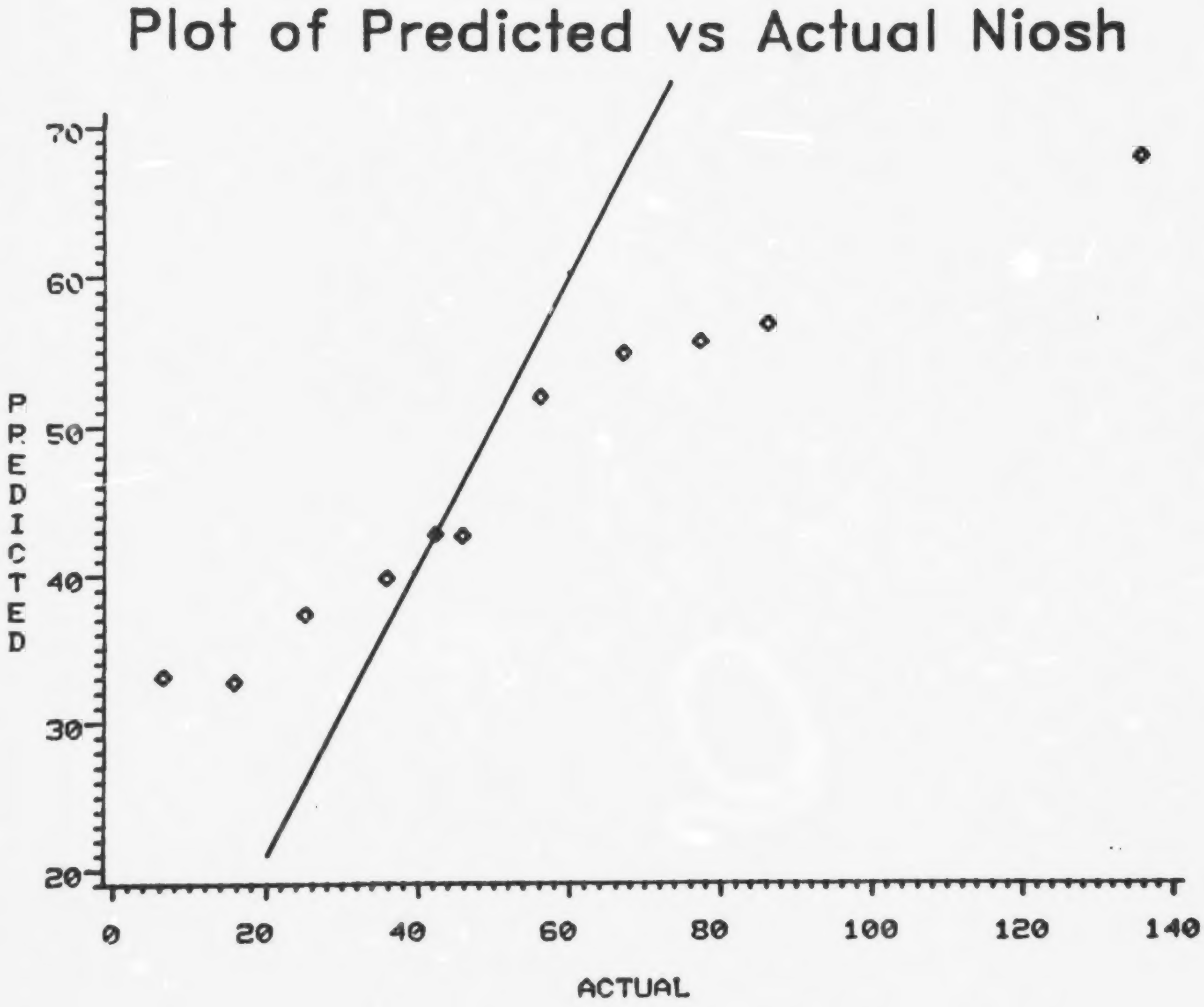
Plot of Predicted vs Actual Niosh
PREDICTED
70
60
50
40
30
20
0
20
40
60
80
100
120
140
ACTUAL

Figure 2.1

(ii) AVERAGE DRAEGER versus all.

To analyze the variation among the average Draeger readings, a model including the variables in the left-hand column of table 2.3 was fit to the data.

```
                         SUM OF            MEAN
SOURCE      DF          SQUARES          SQUARE        F VALUE        PROB>F

MODEL       11          106.862        9.714703          3.031        0.0006
ERROR      198          634.672        3.205412
C TOTAL    209          741.533

     ROOT MSE          1.790367        R-SQUARE         0.1441
     DEP MEAN          1.811297        ADJ R-SQ         0.0966
     C.V.              98.84443


                      PARAMETER        STANDARD    T FOR HO:
VARIABLE    DF         ESTIMATE           ERROR  PARAMETER=0     PROB > |T|

INTERCEP     1         4.220416        2.366595        1.783         0.0761
INTEMP       1        -0.092486        0.080666       -1.147         0.2530
EXTEMP       1  0.0005190092           0.036775        0.014         0.9888
INHUMID      1        -0.035747        0.013010       -2.748         0.0066
MOISTBAR     1         0.094004        0.275397        0.341         0.7332
EXHUMID      1   0.009119831     0.009106051           1.002         0.3178
PERCENT      1  -0.00462544      0.005357413          -0.863         0.3890
UAGE         1        -0.037370        0.011598       -3.222         0.0015
WALLCOND     1         0.319359        0.239456        1.334         0.1838
DAMAGE       1        -0.107617        0.346556       -0.309         0.7574
WM           1         0.219013        0.065338        3.352         0.0010
VAP          1         0.044857        0.075323        0.596         0.5522
```

Table 2.3

The signficant factors in this analysis were internal humidity, age of the UFFI and the average wood moisture. This model was unable to explain a substantial part of the variation in the Draeger readings ($R^2 = .14$).

In a subsequent analysis, only the factors shown in table 2.4 were include.

```
                          SUM OF         MEAN
SOURCE     DF            SQUARES        SQUARE         F VALUE        PROB>F

MODEL       4            128.673     32.168197          13.129        0.0001
ERROR     421           1031.510      2.450142
C TOTAL   425           1160.182

    ROOT MSE            1.565293      R-SQUARE          0.1109
    DEP MEAN            1.453339      ADJ R-SQ          0.1025
    C.V.                107.7032

                       PARAMETER      STANDARD     T FOR H0:
VARIABLE   DF          ESTIMATE          ERROR  PARAMETER=0     PROB > |T|

INTERCEP    1          3.046857       0.649782        4.689         0.0001
INHUMID     1         -0.035429    0.007545958       -4.695         0.0001
UAGE        1         -0.023465    0.006445053       -3.641         0.0003
WM          1          0.145367       0.038058        3.820         0.0002
VAR         1          0.012274       0.033814        0.363         0.7168
```

Table 2.4

The estimated coefficients are given below for those factors having a significant effect.

<u>Factor</u>	<u>95% Confidence Interval</u>
Internal Humidity	-.035 ± .014
Age of UFFI	-.023 ± .012
Average Wood Moisture	.15 ± .08

(iii) Average NIOSH/Average Draeger

The factors include in the analysis of these ratios are shown on the left hand side of table 2.5.

```
                         SUM OF           MEAN
SOURCE      DF          SQUARES         SQUARE       F VALUE       PROB>F

MODEL       12        94929.118       7910.760         2.031       0.0201
ERROR      197           767320       3895.025
C TOTAL    209           862249

     ROOT MSE         62.410135       R-SQUARE        0.1101
     DEP MEAN         53.891424       ADJ R-SQ        0.0559
     C.V.              115.8072

                      PARAMETER       STANDARD    T FOR H0:
VARIABLE    DF         ESTIMATE          ERROR  PARAMETER=0   PROB > |T|

INTERCEP     1        -4.323805      86.096063       -0.050       0.9600
INTEMP       1         4.862075       2.816551        1.726       0.0859
EXTEMP       1         2.863268       1.278266        2.240       0.0262
INHUMID      1        -0.073838       0.472538       -0.156       0.8760
MOISTEAR     1        -6.712914      10.165443       -0.660       0.5098
EXHUMID      1        -0.191192       0.315153       -0.607       0.5446
PERCENT      1         0.211246       0.187066        1.129       0.2602
UAGE         1         0.695668       0.403392        1.725       0.0862
WALLCOND     1        -5.999498       8.498439       -0.706       0.4811
DAMAGE       1         6.385577      12.159335        0.525       0.6001
AGE          1        -4.116018       5.039598       -0.817       0.4151
WM           1        -4.912406       2.284748       -2.150       0.0328
VAR          1        -4.702925       2.621487       -1.794       0.0743
```

Table 2.5

In this analysis, very little of the variation in the ratios was explained by the explanatory factors $(R^2 = .11)$. The only factors exhibiting statistical significance (there is only weak evidence here of an effect) were external temperature and average wood moisture.

Section 2.3 Analysis for Homes with UFFI in Stud Spaces

The analysis for homes in this group was performed for all of the data and subsequently for all of the data with homes from the Maritime Provinces excluded.

(i) NIOSH versus all other factors.

The initial regression model contained all of those factors shown in the left-hand column of table 2.6. In the (a) part of the table, homes from the Maritimes were included and in the (b) part, these homes were excluded.

```
                           SUM OF            MEAN
SOURCE     DF             SQUARES          SQUARE         F VALUE          PROB>F

MODEL      12              257169       21430.770          11.969          0.0001
ERROR     687             1230119        1790.567
C TOTAL   699             1487289

    ROOT MSE            42.315088        R-SQUARE          0.1729
    DEP MEAN            60.954286        ADJ R-SQ          0.1585
    C.V.                 69.42102


                        PARAMETER        STANDARD    T FOR H0:
VARIABLE   DF            ESTIMATE           ERROR   PARAMETER=0     PROB > |T|

INTERCEP    1          -47.112612       26.563187        -1.774         0.0766
AVDRAEG     1            4.585206        0.973254         4.711         0.0001
INTEMP      1            3.037673        0.900319         3.374         0.0008
EXTEMP      1            0.277884        0.302906         0.917         0.3593
INHUMID     1           -0.050547        0.180661        -0.280         0.7797
MOISTBAR    1           -0.232361        4.253613        -0.055         0.9565
EXHUMID     1            0.017849        0.106875         0.167         0.8674
PERCENT     1            0.226531        0.064575         3.508         0.0005
UAGE        1           -0.159671        0.118935        -1.343         0.1799
WALLCOND    1            6.441926        2.771846         2.324         0.0204
DAMAGE      1            1.954968        4.830435         0.405         0.6858
WH          1           -2.370983        0.703744        -3.369         0.0008
VAP         1            3.633191        0.792818         4.583         0.0001
```

Table 2.6(a)

```
                         SUM OF          MEAN
SOURCE       DF         SQUARES        SQUARE         F VALUE        PROB>F

MODEL        12          280031     23335.694          11.953        0.0001
ERROR       483          942983      1952.346
C TOTAL     495         1223014

     ROOT MSE         44.185362      R-SQUARE          0.2290
     DEP MEAN         60.144153      ADJ R-SQ          0.2098
     C.V.              73.46576

                      PARAMETER      STANDARD    T FOR H0:
VARIABLE     DF        ESTIMATE         ERROR   PARAMETER=0    PROB > |T|

INTERCEP      1      -53.069537     34.395818        -1.543        0.1235
AVDRAEG       1        5.089595      1.206176         4.220        0.0001
INTEMP        1        4.186682      1.246230         3.359        0.0008
EXTEMP        1       -0.610242      0.475780        -1.283        0.2002
INHUMID       1        0.021287      0.223399         0.095        0.9241
MOISTEAR      1       -4.861596      5.496796        -0.884        0.3769
EXHUMID       1       -0.132035      0.139236        -0.948        0.3435
PERCENT       1        0.182847      0.080230         2.279        0.0231
UAGE          1       -0.348912      0.161999        -2.154        0.0318
WALLCOND      1        4.631640      3.273079         1.415        0.1577
DAMAGE        1       -0.415206      5.704542        -0.073        0.9420
WM            1       -2.140544      0.951605        -2.249        0.0249
VAP           1        5.700344      1.059902         5.378        0.0001
```

Table 2.6(b)

In these two tables there is some inconsistency in the significant factors. This demonstrates the effect of the correlation between the explanatory variables. The analysis was redone to include average draeger, interval temperature, vapour level, percentage of the walls insulated with UFFI and the average wood moisture level. Tables 2.7(a) and (b) show the results of this analysis.

```
                          SUM OF          MEAN
SOURCE      DF           SQUARES        SQUARE         F VALUE        PROB>F

MODEL        5            283564     56712.851          33.520        0.0001
ERROR      940           1590404      1691.919
C TOTAL    945           1873968

     ROOT MSE          41.132945      R-SQUARE          0.1513
     DEP MEAN          59.964059      ADJ R-SQ          0.1468
     C.V.                 68.596

                       PARAMETER      STANDARD     T FOR H0:
VARIABLE    DF          ESTIMATE         ERROR   PARAMETER=0     PROB > |T|

INTERCEP     1        -30.834677     16.302086        -1.891         0.0589
AVDRAEG      1          4.124061      0.747917         5.514         0.0001
INTEMP       1          2.750573      0.746146         3.686         0.0002
VAP          1          3.661550      0.601219         6.090         0.0001
PERCENT      1          0.199906      0.054034         3.700         0.0002
WM           1         -2.410302      0.575748        -4.186         0.0001
```

Table 2.7(a)

```
                          SUM OF          MEAN
SOURCE      DF           SQUARES        SQUARE         F VALUE        PROB>F

MODEL        5            276204     55240.796          29.959        0.0001
ERROR      692           1275978      1843.898
C TOTAL    697           1552182

     ROOT MSE          42.940637      R-SQUARE          0.1779
     DEP MEAN          58.535817      ADJ R-SQ          0.1720
     C.V.               73.35788

                       PARAMETER      STANDARD     T FOR H0:
VARIABLE    DF          ESTIMATE         ERROR   PARAMETER=0     PROB > |T|

INTERCEP     1        -48.852479     21.019220        -2.324         0.0204
AVDRAEG      1          4.813394      0.902339         5.334         0.0001
INTEMP       1          3.309372      0.999002         3.313         0.0010
VAP          1          4.230685      0.721007         5.868         0.0001
PERCENT      1          0.162683      0.065619         2.479         0.0134
WM           1         -2.033666      0.748863        -2.716         0.0068
```

Table 2.7(b)

The factors with coefficients significantly different from zero are given below.

Factor	95% Confidence Interval (Maritimes in)	 (Maritimes out)
Average Draeger	4.12±1.5	4.81±1.8
Internal Temperature	2.75±1.5	3.31±2.0
Average Vapour level	3.66±1.2	4.23±1.4
Percent UFFI	.20± .10	.16± .13
Wood Moisture	-2.41±1.15	-2.03±1.5

To examine the possibility of using this model to predict NIOSH levels from the explanatory variables, NIOSH levels were grouped into classes [0,10],[10,20),...,[190 and up) and the average levels of the predicted and actual NIOSH values in each class were calculated. The predicted average was plotted against the actual average in figures 2.2 (Maritimes in) and 2.3 (Maritimes out). Once again this model underpredicts high values and overpredicts low values indicating (perhaps) a significant missing factor.

```
STUDSP=1

PLOT OF PH*NM    LEGEND: A = 1 OBS, B = 2 OBS, ETC.
```

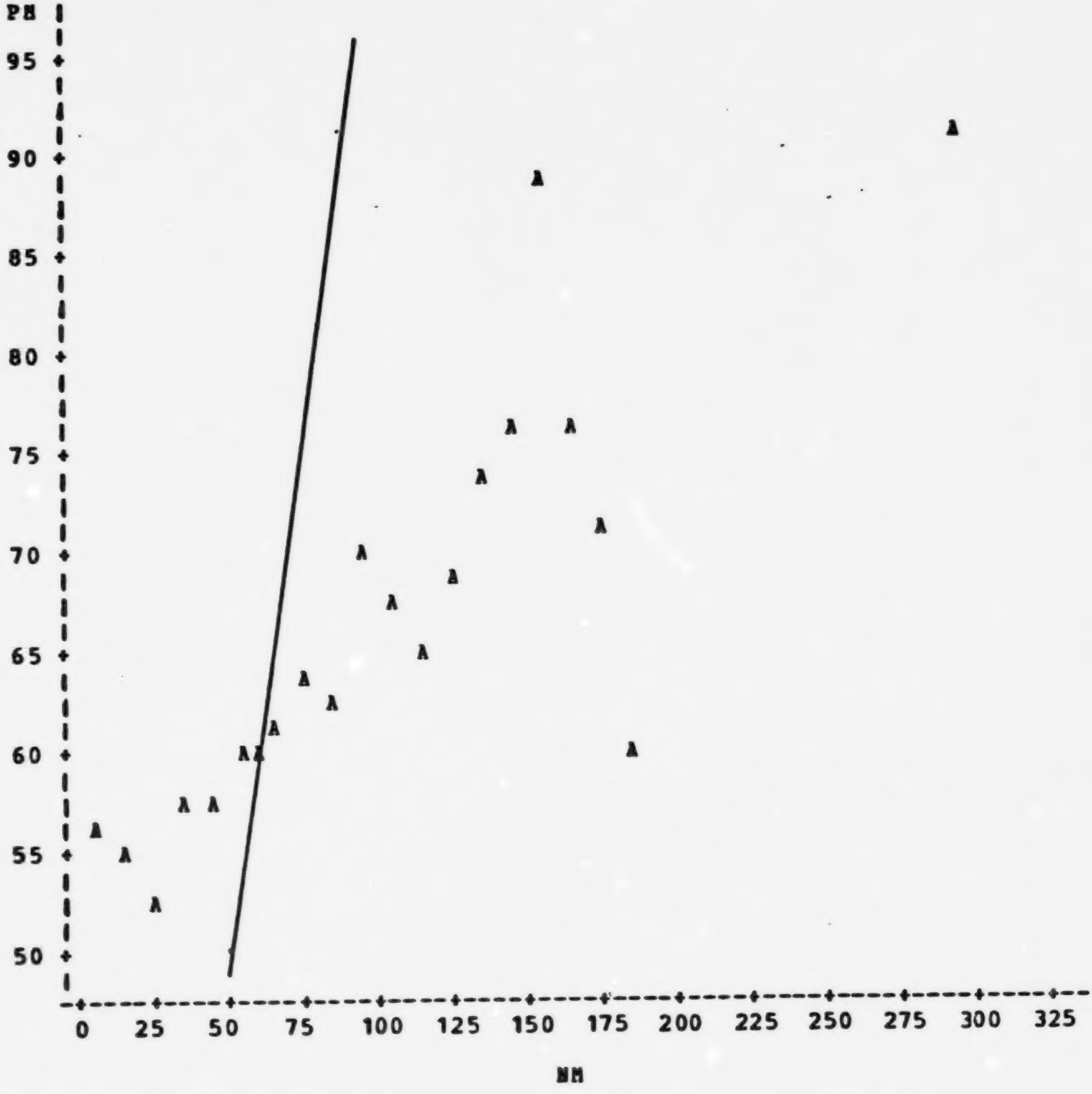

Figure 2.2

STUDSP=1

PLOT OF PH*NH   LEGEND: A = 1 OBS, B = 2 OBS, ETC.

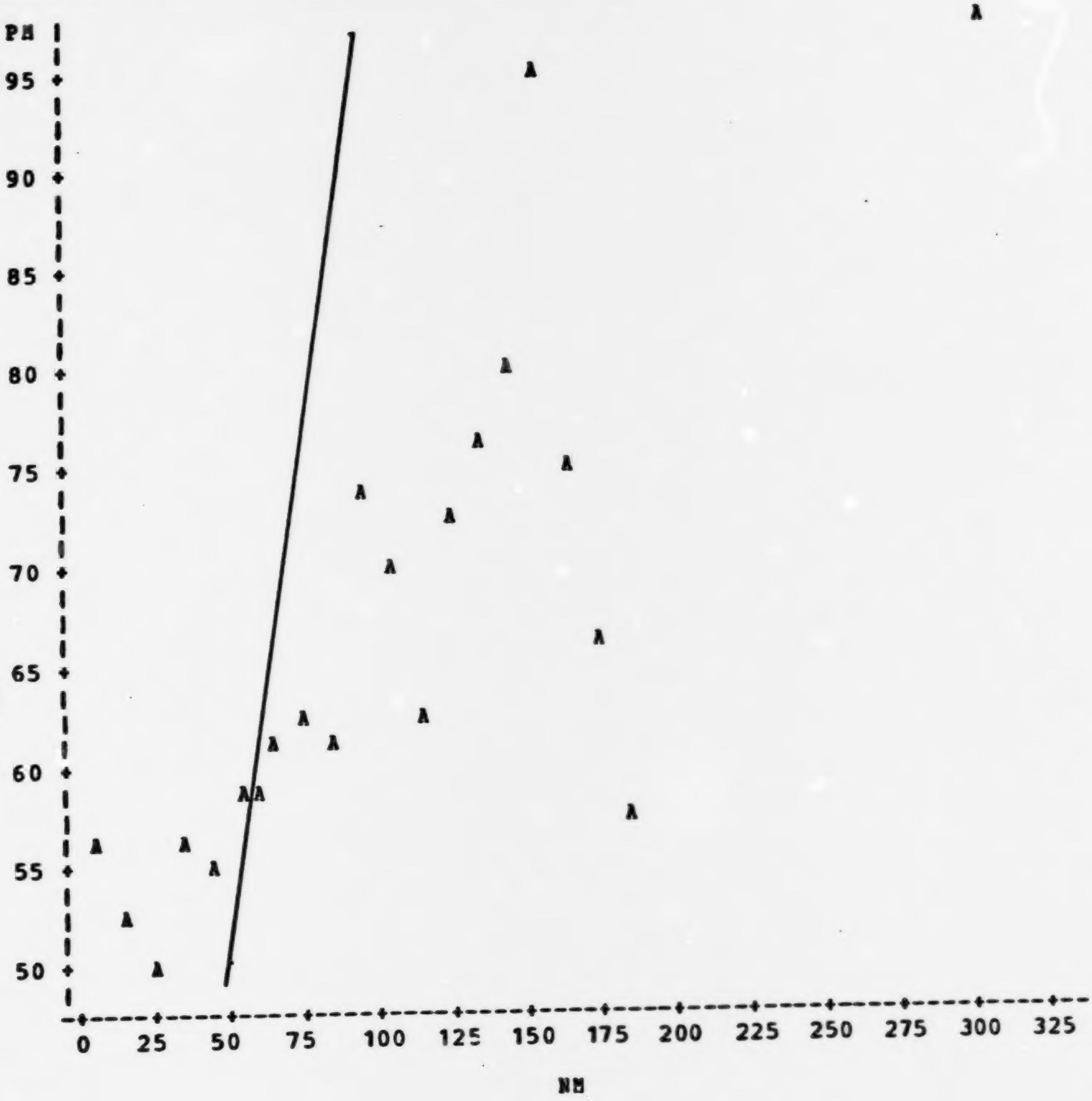

Figure 2.3

(ii) Average Draeger versus all except NIOSH.

Tables 2.8(a) and (b) give the results of fitting a model with dependent variable average Draeger level and explanatory variables given in the left hand margin of the table. Table (a) includes all homes in the class with complete information and table (b) excludes homes from the Maritime Provinces.

```
                        SUM OF           MEAN
SOURCE      DF         SQUARES         SQUARE        F VALUE          PROB>F

MODEL       11         474.985      43.180481         15.737          0.0001
ERROR      689        1890.507       2.743842
C TOTAL    700        2365.493

    ROOT MSE          1.656455       R-SQUARE         0.2008
    DEP MEAN          2.634026       ADJ R-SQ         0.1880
    C.V.              62.88682


                     PARAMETER       STANDARD    T FOR H0:
VARIABLE    DF        ESTIMATE          ERROR  PARAMETER=0     PROB > |T|

INTERCEP     1        0.471642       1.038163        0.454          0.6498
INTEMP       1        0.069481       0.035120        1.978          0.0483
EXTEMP       1        0.012872       0.011847        1.086          0.2777
INHUMID      1        0.011604    0.007057948        1.644          0.1006
MOISTBAR     1       -0.251302       0.166190       -1.512          0.1310
EXHUMID      1    -0.00632324    0.004176597       -1.514          0.1305
PERCENT      1    0.008416583    0.002507138        3.357          0.0008
UAGE         1       -0.041584    0.004375256       -9.504          0.0001
WALLCOND     1        0.035440       0.108428        0.327          0.7435
DAMAGE       1        0.254151       0.187933        1.352          0.1767
WM           1       -0.037779       0.027507       -1.373          0.1701
VAP          1        0.150775       0.030499        4.944          0.0001
```

Table 2.8(a)

```
                         SUM OF          MEAN
SOURCE      DF          SQUARES        SQUARE         F VALUE        PROB>F

MODEL       11          383.267     34.842488          12.592        0.0001
ERROR      485         1341.999      2.767008
C TOTAL    496         1725.266

    ROOT MSE           1.663433      R-SQUARE          0.2221
    DEP MEAN           2.595725      ADJ R-SQ          0.2045
    C.V.               64.08356


                      PARAMETER      STANDARD     T FOR H0:
VARIABLE    DF         ESTIMATE         ERROR   PARAMETER=0     PROB > |T|

INTERCEP     1        -1.268140      1.291906        -0.982         0.3268
INTEMP       1         0.150573      0.046376         3.247         0.0012
EXTEMP       1         0.016562      0.017854         0.926         0.3552
INHUMID      1      0.007671456   0.008401205         0.937         0.3493
MOISTEAR     1        -0.160978      0.206742        -0.779         0.4366
EXHUMID      1      -0.00180377   0.005240822        -0.344         0.7309
PERCENT      1      0.007467657   0.003001178         2.488         0.0132
UAGE         1        -0.046818   0.005709218        -8.200         0.0001
WALLCOND     1         0.076514      0.123080         0.622         0.5345
DAMAGE       1         0.166592      0.213418         0.781         0.4354
WM           1        -0.014899      0.035815        -0.416         0.6776
VAP          1         0.132363      0.039444         3.356         0.0009
```

Table 2.8(b)

The significant factors were internal temperature, percent of UFFI in the walls, the age of the UFFI and the average vapour level. These results were consistent whether or not the Maritimes were included or excluded and in the subsequent analysis (table 2.9) all homes were included.

```
                          SUM OF          MEAN
SOURCE      DF           SQUARES        SQUARE         F VALUE        PROB>F

MODEL        5           643.553       128.711          44.321        0.0001
ERROR      900          2613.635      2.904039
C TOTAL    905          3257.188

      ROOT MSE          1.704124      R-SQUARE          0.1976
      DEP MEAN          2.686830      ADJ R-SQ          0.1931
      C.V.              63.42507


                       PARAMETER      STANDARD    T FOR HO:
VARIABLE    DF          ESTIMATE         ERROR   PARAMETER=0    PROB > |T|

INTERCEP     1          0.729152      0.704838         1.034        0.3012
INTEMP       1          0.066887      0.031342         2.134        0.0331
PERCENT      1       0.007859399   0.002269914         3.462        0.0006
UAGE         1         -0.039864   0.003965169       -10.053        0.0001
WM           1         -0.040030      0.024475        -1.636        0.1023
VAP          1          0.216365      0.024602         8.795        0.0001
```

Table 2.9

The coefficients of the significant factors are:

Factor	95% confidence interval
Percent of UFFI	.0079±.0044
Age of UFFI	-.040 ±.008
Average vapour level	.22 ±.05

(iii) Average NIOSH/Average Draeger versus all other factors.

The analysis of these data are included in tables 2.10(a) and 2.10(b).

```
                        SUM OF           MEAN
SOURCE       DF        SQUARES          SQUARE        F VALUE       PROB>F

MODEL        12      62679.898        5223.325          2.560       0.0019
ERROR       685        1397682        2040.411
C TOTAL     697        1460362

     ROOT MSE        45.170912        R-SQUARE         0.0429
     DEP MEAN        37.791481        ADJ R-SQ         0.0262
     C.V.             119.5267

                     PARAMETER        STANDARD     T FOR H0:
VARIABLE     DF       ESTIMATE           ERROR   PARAMETER=0     PROB > |T|

INTERCEP      1      58.200949       29.499656         1.973         0.0489
INTEMP        1       0.535616        0.961428         0.557         0.5776
EXTEMP        1       0.238329        0.324415         0.735         0.4628
INHUMID       1      -0.244887        0.193045        -1.269         0.2050
MOISTBAR      1       0.071308        4.869654         0.015         0.9883
EXHUMID       1       0.055365        0.113939         0.486         0.6272
PERCENT       1      -0.077389        0.068561        -1.129         0.2594
UAGE          1       0.415614        0.119808         3.471         0.0006
WALLCOND      1       5.282781        2.974503         1.776         0.0762
DAMAGE        1     -15.484851        5.153027        -3.005         0.0028
AGE           1      -1.067994        2.013432        -0.530         0.5960
WM            1      -0.357066        0.751780        -0.475         0.6350
VAR           1      -0.243523        0.835181        -0.292         0.7707
```

Table 2.10(a)

```
                             SUM OF                 MEAN
SOURCE        DF            SQUARES               SQUARE          F VALUE         PROB>F

MODEL         12          68033.422             5669.452            2.433         0.0035
ERROR        482            1123155             2330.198
C TOTAL      494            1191189

      ROOT MSE            48.272124             R-SQUARE           0.0571
      DEP MEAN            38.658706             ADJ R-SQ           0.0336
      C.V.                 124.8674


                          PARAMETER             STANDARD      T FOR H0:
VARIABLE      DF           ESTIMATE                ERROR    PARAMETER=0      PROB > |T|

INTERCEP       1          70.051517            38.838667          1.804          0.0719
INTEMP         1           0.386330             1.350334          0.286          0.7749
EXTEMP         1           0.430367             0.519663          0.828          0.4080
INHUMID        1          -0.309167             0.244800         -1.263          0.2072
MOISTBAR       1          -7.509652             6.565646         -1.144          0.2533
EXHUMID        1           0.094295             0.152375          0.619          0.5363
PERCENT        1          -0.092268             0.087270         -1.057          0.2909
UAGE           1           0.525585             0.166686          3.153          0.0017
WALLCOND       1           6.018526             3.591746          1.676          0.0945
DAMAGE         1         -17.171253             6.231383         -2.756          0.0061
AGE            1          -1.712131             2.609054         -0.656          0.5120
WM             1          -0.675040             1.042442         -0.648          0.5172
VAR            1           0.190989             1.146307          0.167          0.8677
```

Table 2.10(b)

In both cases, the explanatory variables were able to account for a very small proportion of the variation in the ratios. The factors which appear significant are damage to the cavity and the age of the UFFI. The effect of these factors is very small however.

Section 2.4. Analysis for Homes with UFFI between Brick Walls

In this class of home, there were no houses in the Maritimes in the original analysis os that this analysis was completed for all homes.

(i) NIOSH versus all other factors.

The analysis given in table 2.11 shows that there were no significant factors to explain the variation in the NIOSH values.

```
                      SUM OF         MEAN
SOURCE      DF       SQUARES       SQUARE       F VALUE        PROB>F

MODEL       12     16757.352     1396.446         1.112        0.3657
ERROR       64     80364.726     1255.699
C TOTAL     76     97122.078

   ROOT MSE        35.435841     R-SQUARE        0.1725
   DEP MEAN        52.623377     ADJ R-SQ        0.0174
   C.V.             67.33859


                   PARAMETER     STANDARD    T FOR H0:
VARIABLE    DF      ESTIMATE        ERROR  PARAMETER=0    PROB > |T|

INTERCEP     1     66.361917    90.165106        0.736        0.4644
INTEMP       1      1.537018     3.081283        0.499        0.6196
EXTEMP       1     -1.322103     1.364763       -0.969        0.3363
INHUMID      1     -0.745601     0.514720       -1.449        0.1522
MOISTBAR     1      0.503222    10.086399        0.050        0.9604
EXHUMID      1     -0.057379     0.333219       -0.172        0.8633
PERCENT      1      0.064645     0.179796        0.360        0.7204
UAGE         1     -0.238962     0.430422       -0.555        0.5807
AVDRAEG      1      1.781931     1.857070        0.960        0.3403
WALLCOND     1     -1.327763     6.048838       -0.220        0.8270
DAMAGE       1     -7.357026    12.141609       -0.606        0.5467
WS           1     -0.619327     2.923572       -0.212        0.8329
VAP          1      4.710135     2.806981        1.678        0.0982
```

Table 2.11

In further modelling, the variables internal humidity and average vapour level became slightly signigicant. It is interesting that the average Draeger level seemed unrelated to the NIOSH values in this (small) group of homes.

(ii) Average Draeger versus other factors.

The analysis for this variable is shown in table 2.12. The only factor which is significant is the age of UFFI with coefficient -.074 ± .054.

```
                           SUM OF             MEAN
SOURCE      DF            SQUARES            SQUARE           F VALUE          PROB>F

MODEL       11            108.836          9.894222             1.766          0.0730
ERROR       65            364.107          5.601647
C TOTAL     76            472.944

     ROOT MSE            2.366780          R-SQUARE            0.2301
     DEP MEAN            2.872939          ADJ R-SQ            0.0998
     C.V.                82.33039


                        PARAMETER          STANDARD    T FOR H0:
VARIABLE    DF           ESTIMATE             ERROR  PARAMETER=0      PROB > |T|

INTERCEP     1           6.860933          5.961749         1.151          0.2540
INTEMP       1 0.0008736526          0.205801         0.004          0.9966
EXTEMP       1           0.127064          0.089780         1.415          0.1619
INHUMID      1          -0.049765          0.033820        -1.471          0.1460
MOISTBAL     1          -0.271625          0.672833        -0.404          0.6875
EXHUMID      1           0.035051          0.021827         1.606          0.1132
PERCENT      1          -0.011700          0.011921        -0.981          0.3300
UAGE         1          -0.074931          0.027204        -2.754          0.0076
WALLCOND     1           0.346914          0.401709         0.863          0.3911
DAMAGE       1          -1.150366          0.798294        -1.441          0.1544
WM           1          -0.260577          0.192571        -1.354          0.1805
VAP          1           0.281564          0.184198         1.529          0.1312
```

Table 2.12

(iii) Average NIOSH/Average Draeger versus other factors.

The analysis of the ratio showed no significant factors.

```
                        SUM OF           MEAN
SOURCE      DF         SQUARES         SQUARE         F VALUE         PROB>F

MODEL       12       35507.961       2958.997           0.527         0.8998
ERROR       64          359559       5618.114
C TOTAL     76          395067

    ROOT MSE         74.954080       R-SQUARE          0.0899
    DEP MEAN         43.716744       ADJ R-SQ         -0.0806
    C.V.              171.4539

                     PARAMETER       STANDARD    T FOR H0:
VARIABLE    DF        ESTIMATE          ERROR   PARAMETER=0     PROB > |T|

INTERCEP     1         216.557        189.589         1.142         0.2576
INTEMP       1       -4.427092       6.521300        -0.679         0.4997
EXTEMP       1       -2.596575       2.866237        -0.906         0.3684
INHUMID      1       -0.975667       1.105557        -0.883         0.3806
MOISTBAR     1       12.425468      21.646379         0.574         0.5680
EXHUMID      1       -0.540633       0.701079        -0.771         0.4435
PERCENT      1     0.005910665       0.377606         0.016         0.9876
UAGE         1        0.586223       0.861637         0.680         0.4987
WALLCOND     1       -1.725846      12.864799        -0.134         0.8939
DAMAGE       1      -17.291225      25.814950        -0.670         0.5054
AGE          1        0.327043       8.414148         0.039         0.9691
WM           1        0.390106       6.185708         0.063         0.9499
VAR          1        7.741334       5.836816         1.326         0.1895
```

Table 2.13

Section 2.5 Summary

To summarize the data in this section succinctly seemed very difficult. A severe selection had to be made based on those significant results discovered earlier. Here we present a few graphical summaries of the apparent relationshipes between formaldehyde measures and other factors.

In all cases, the data were grouped into classes (for example, by average Draeger level) and then the mean of one variable (say average NIOSH) for all homes in a class was plotted against the mean of the classification variable.

The plots give are:

Figure 2.4:	Average NIOSH versus average Draeger.
Figure 2.5:	Average Draeger versus age of UFFI (months).
Figure 2.6:	Average Draeger versus average vapour.
Figure 2.7:	Average Draeger versus wood moisture.

In all cases, it should be recalled that the class of homes with UFFI between brick walls is very small (162) and that the relationships shown by the graphs are doubtful.

Plot of Average Niosh vs Average Draeger
By Cavity Type

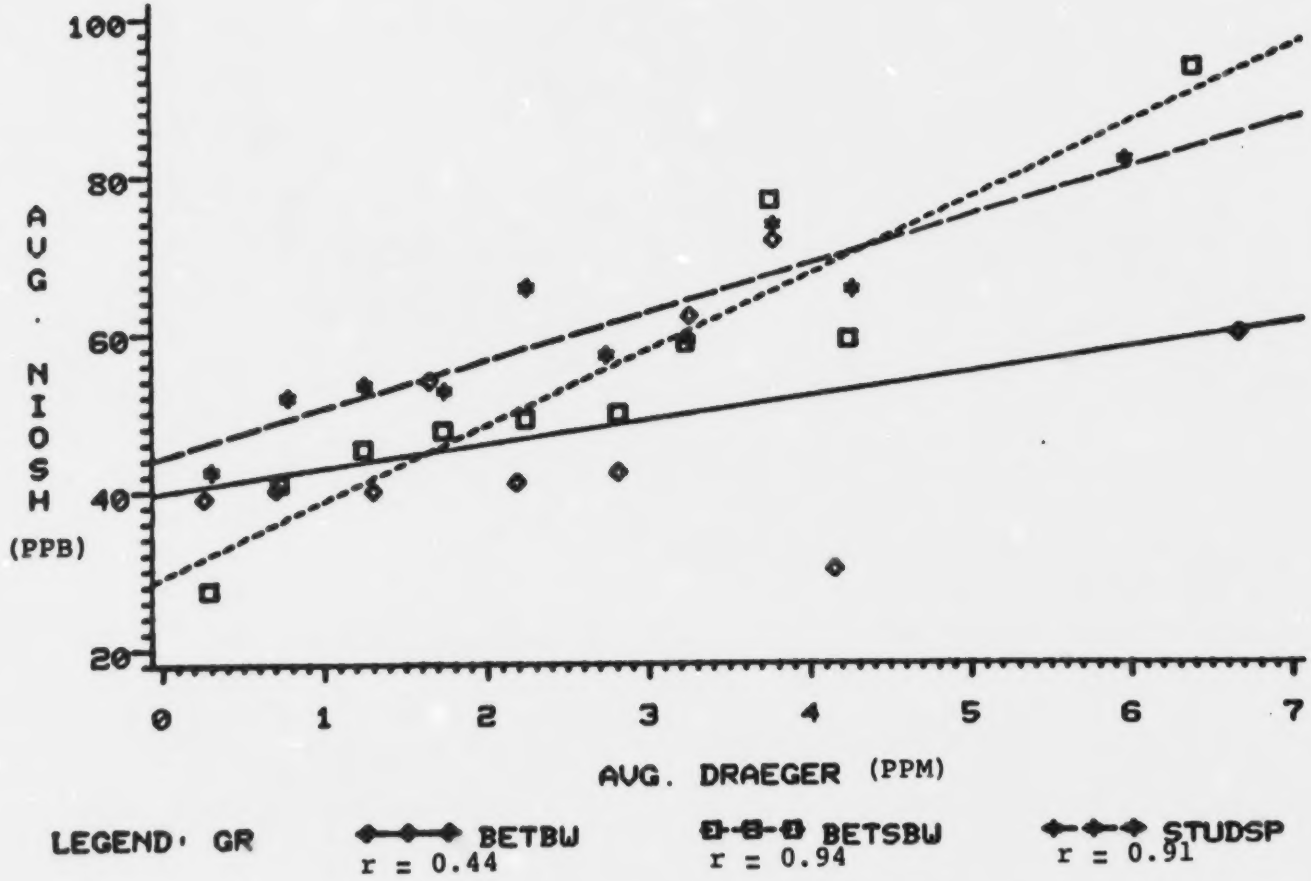

Figure 2.4

Plot of Average Draeger vs Uffi Age
By Cavity Type

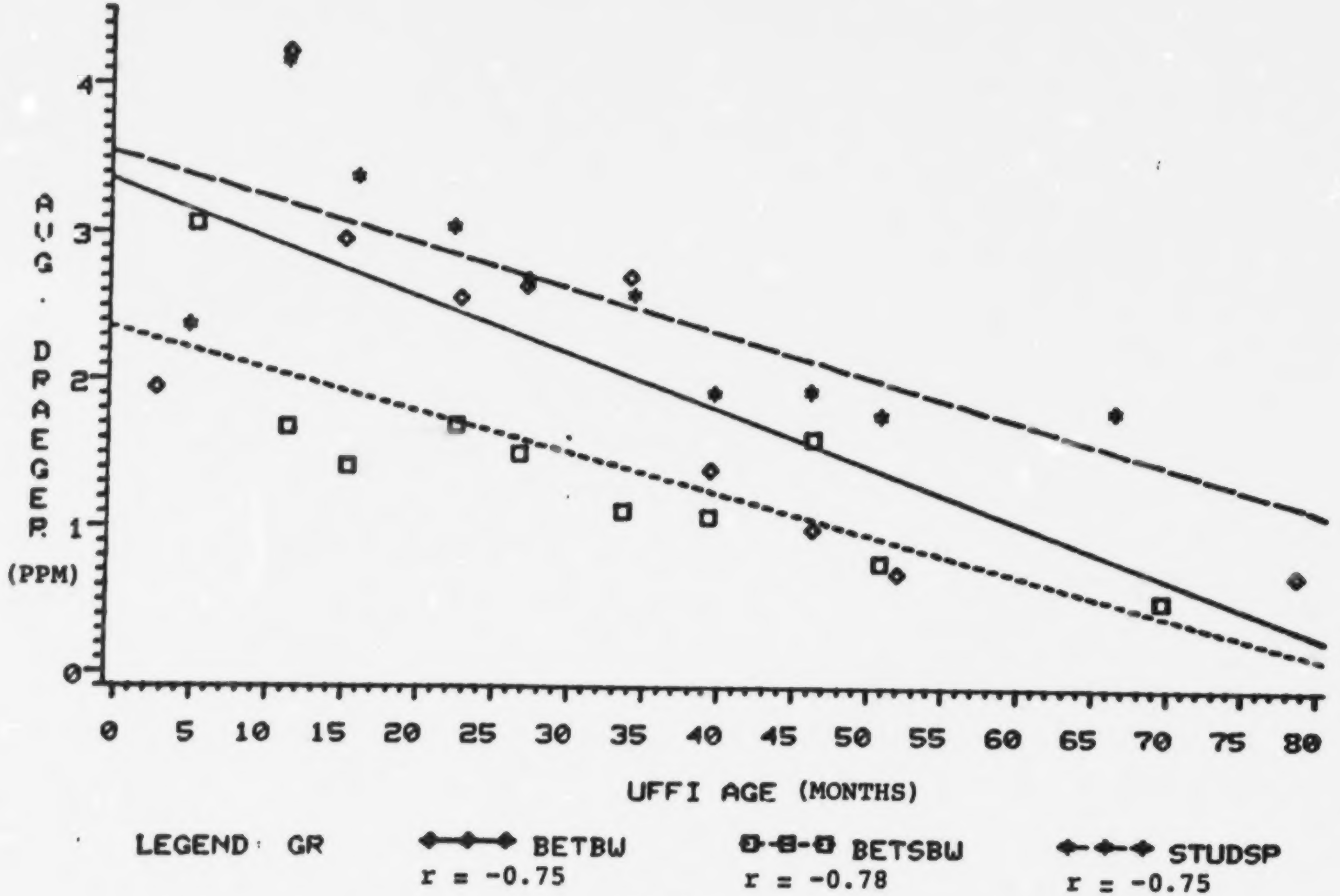

Figure 2.5

Plot of Average Draeger vs Average Vapour
By Cavity Type

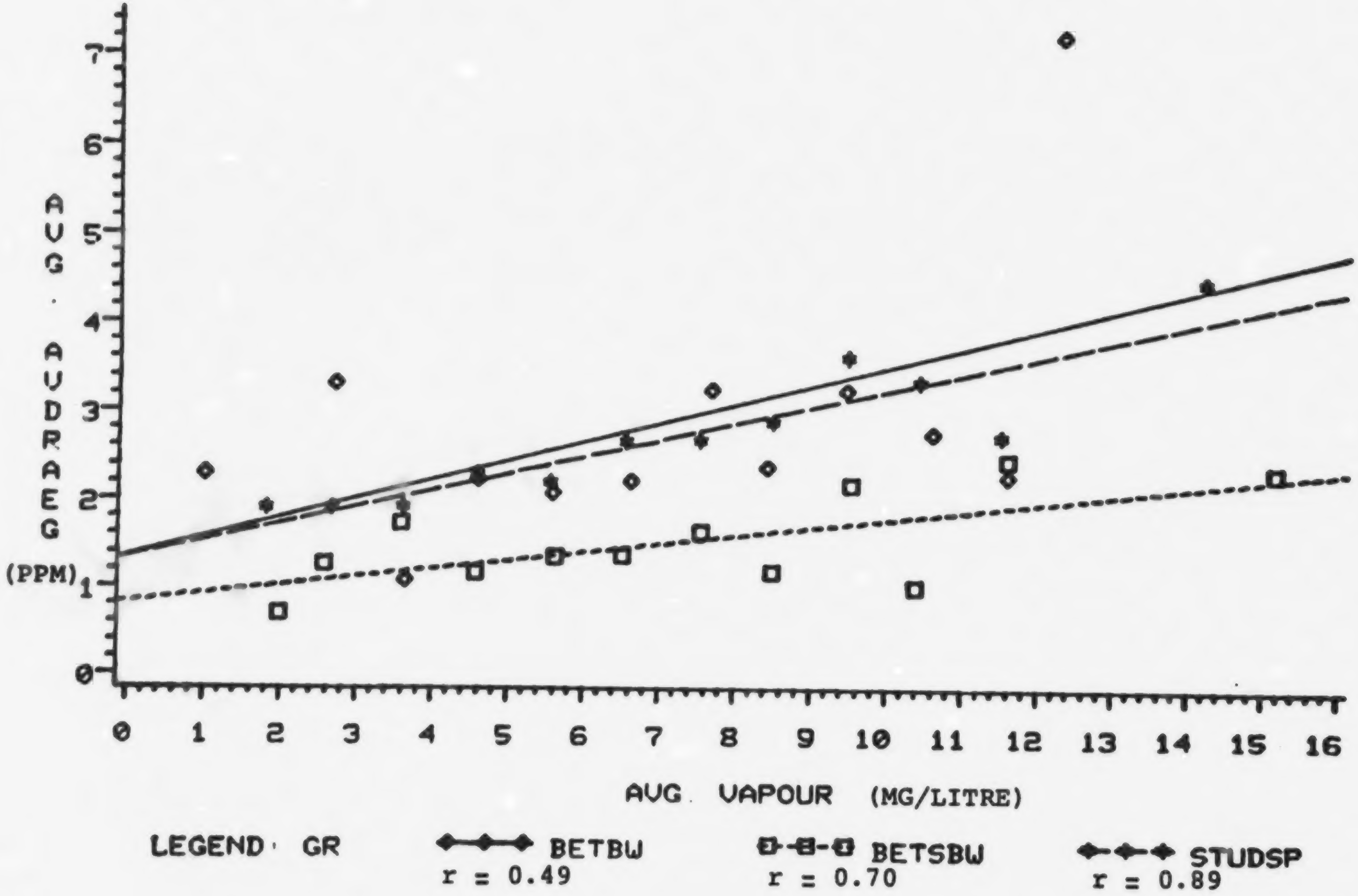

Figure 2.6

Plot of Average Draeger vs Average Wood Moisture By Cavity Type

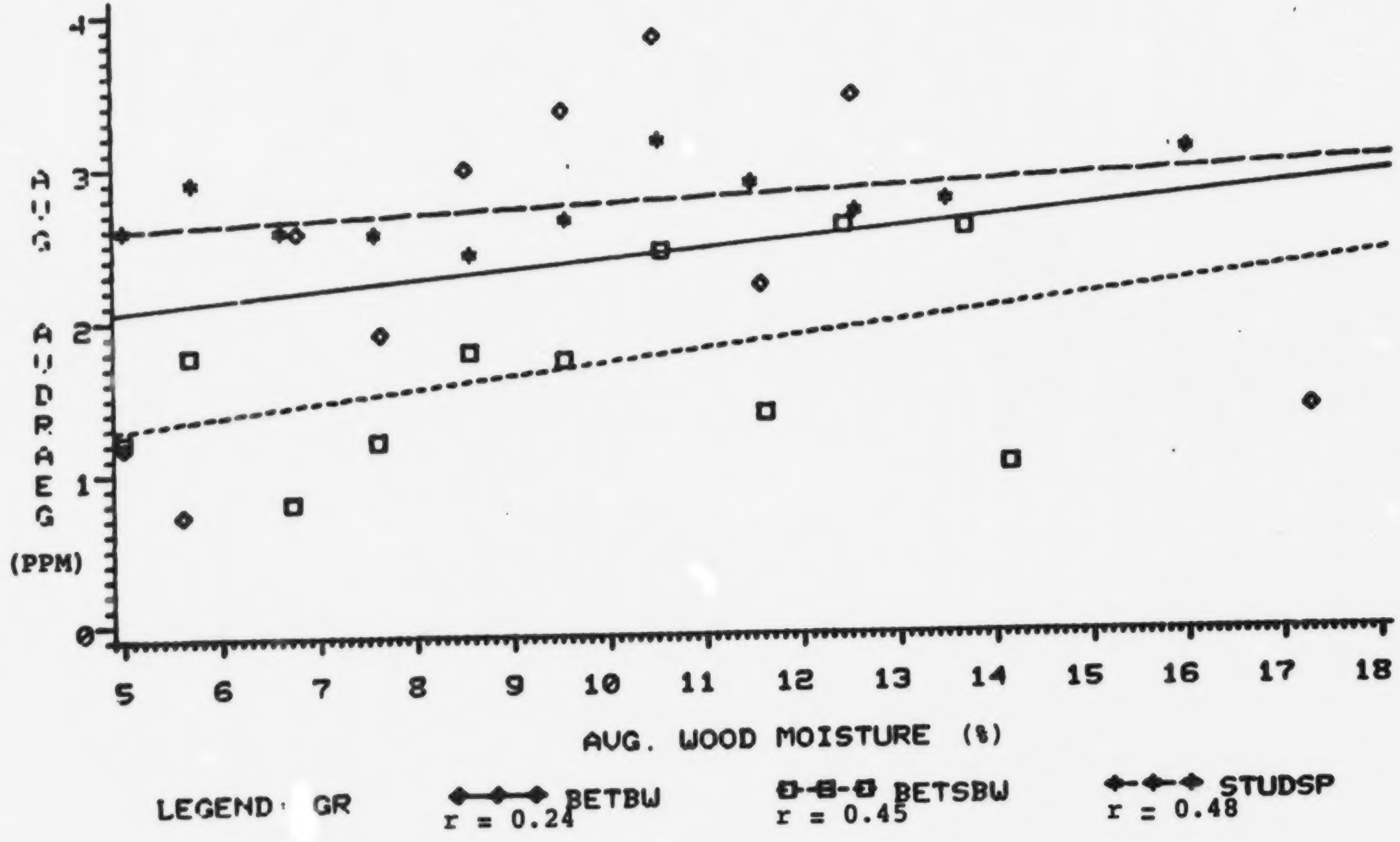

Figure 2.7

Section 3. Miscellaneous Analyses

(i) NIOSH and Draeger readings by Manufacturer.

Tables 3.1 and 3.2 present the average NIOSH readings and the average Draeger readings for foams manufactured by different companies (here labelled 1,2,3,5,6,7,9).

There is no evidence of systematically high or low results for any particular manufacturer. Any orderings in the National averages are distorted once a province by province examination is made.

(ii) NIOSH and Spoiled Draeger Results for Field Teams

Of the homes with valid Draeger readings, the average of the proportion spoiled was .037.

There were a large number of field terms and the computer listing (Figure 3.1) gives the following information.

Column Heading	Interpretation
Team	team number as coded
NPERCSP	number of homes for that team with valid Draeger readings
NNIOSH	number of homes for that team with valid NIOSH readings
MPERCSP	average of the proportion of spoiled (number spoiled/number of readings) Draeger values for that team
MNIOSH	the average of the NIOSH values taken by that team
SNIOSH	the standard deviation of the NIOSH values taken by that team.

(iii) Spoiled versus Average Draeger

There was a significant difference between the average Draeger results for those homes in which no readings were spoiled compared to those in which at least one was spoiled.

	Number	Average Draeger
none spoiled	1662	2.34
at least one spoiled	235	1.59

	MANUFACTURER							
Province	1	2	3	5	6	7	9	Mean
Nfld.	73.5	46.8	54.3	-	46.9	-	148.5*	60.1
N.S.	41.8*	79.3	87.0*	-	85.8	63.0*	47.5*	78.2
P.E.I.	-	46.9	-	-	21.0*	-	-	42.6
N.B.	61.3	60.1	62.4	111.8*	44.5	-	74.5*	59.8
Que.	30.2	40.9	28.8	22.5	28.3	6.0*	35.7	34.3
Ont.	63.1	63.0	54.7	71.6	58.7	62.8*	76.5	62.9
Man.	39.8	42.5	73.9*	-	38.3	17.2*	40.8	41.3
Sask.	29.4*	42.9	-	-	30.3	-	-	34.2
Alta.	33.1*	66.8	-	-	36.0	-	19.0*	55.2
B.C.	36.6	-	50.2*	-	36.3	-	35.9	36.9
Canada	41.8	55.6	50.6	40.8	47.7	44.4	51.3	
	(301)	(618)	(31)	(74)	(228)	(8)	(56)	

Table 3.1 Average NIOSH readings by manufacturer and province.

Note: * indicates the average is based on fewer than 5 homes.

MANUFACTURER

Province	1	2	3	5	6	7	9	Mean
Nfld.	3.70	2.29	2.62*	-	3.72	-	2.25*	3.29
N.S.	2.60*	2.32	1.20*	-	2.71	2.18*	2.17*	2.36
P.E.I.	-	0.95	-	-	3.67*	-	-	1.40
N.B.	2.93	3.30	2.62	4.59*	2.47	-	0.72*	3.04
Que.	1.27	2.36	0.70	0.95	0.93	0.20*	1.55	1.72
Ont.	2.14	2.23	1.18	2.27	1.89	1.25*	2.37	2.13
Man.	3.44	2.98	2.07*	-	2.62	4.70*	2.77	2.88
Sask.	2.67*	1.61	-	-	3.08	-	-	2.55
Alta.	1.99*	2.31	-	-	3.02	-	1.13*	2.35
B.C.	3.27	-	3.42*	-	2.80	-	2.67	3.06
Canada	2.08	2.38	1.75	1.50	2.29	2.21	2.08	
	(294)	(614)	(28)	(71)	(227)	(8)	(54)	

Table 3.2 Average Draeger readings by manufacturer and province.

Note: * indicates the average is based on fewer than 5 homes.

Listing 3.1 Field Team Analysis

```
OBS TEAM _TYPE_ _FREQ_ NPERCSP NNIOSH  MPERCSP   MNIOSH  SNIOSH

  1    .    0     1922   1778    1807  0.0375381  52.831  42.804
  2    1    1        2      2       2  0.0000000  81.250   4.596
  3    2    1        8      6       6  0.0000000 107.250  38.847
  4    3    1        3      3       3  0.0000000  76.667  10.408
  5    4    1        1      1       1  0.0000000  20.500    .
  6    5    1       25     25      25  0.0120000  80.400  28.901
  7    6    1        7      4       4  0.0000000 128.625  53.773
  8    7    1        8      6       6  0.0000000  62.583  32.592
  9    8    1        3      3       3  0.0000000 105.667  25.325
 10    9    1       43     38      43  0.0052632  37.953  17.746
 11   10    1        9      9       9  0.0222222  56.667  23.335
 12   11    1       25     25      25  0.0000000  73.800  47.964
 13   12    1       25     25      25  0.0000000  47.200  24.794
 14   13    1       34     21      21  0.0000000  63.024  36.176
 15   14    1       34     33      34  0.0648485  31.647  12.791
 16   15    1        4      4       4  0.0000000  40.250  24.675
 17   16    1        6      6       6  0.0000000  74.583  22.135
 18   17    1       20     19      19  0.0000000  58.684  29.195
 19   19    1       14     10      10  0.0000000  53.500  15.820
 20   20    1        2      2       2  0.0000000  83.250  63.593
 21   21    1        3      3       3  0.0000000 107.333  55.103
 22   22    1       18     17      17  0.0000000  72.324  30.775
 23   23    1       23     23      23  0.0130435  65.435  37.565
 24   24    1       13      7       7  0.0000000  48.571  38.914
 25   25    1       41     40      41  0.0850000  30.927  11.127
 26   26    1        1      1       1  0.0000000  35.000    .
 27   27    1       29     22      22  0.0000000  74.614  35.015
 28   28    1       10      7       7  0.0000000  49.071  27.202
 29   29    1        2      2       2  0.0000000  97.500  81.317
 30   30    1       20     20      20  0.0100000  76.675  40.490
 31   31    1        2      2       2  0.0000000  69.750  38.537
 32   32    1        2      2       2  0.0000000  71.750  68.236
 33   33    1        2      2       2  0.0000000  59.500  16.263
 34   35    1       13     13      13  0.0000000  50.077  20.977
 35   36    1        6      6       6  0.0185185  84.167  57.220
 36   37    1        2      2       2  0.0000000  37.500   3.536
 37   38    1        7      6       7  0.0000000  55.714  25.402
 38   39    1       16     16      16  0.0000000  62.188  25.164
 39   40    1       20     20      20  0.0000000  56.275  25.636
 40   41    1        5      5       5  0.0000000 156.200 115.926
 41   42    1        1      1       1  0.0000000  24.000    .
 42   43    1       33     22      23  0.0090909  72.826  35.516
 43   44    1        2      2       2  0.0000000  61.250  14.496
 44   45    1       22     22      22  0.0000000  56.682  34.529
 45   46    1        1      1       1  0.0000000  36.000    .
 46   47    1       15     14      15  0.0129870  82.333  31.672
 47   48    1        1      1       1  0.0000000  68.500    .
 48   49    1       11      4       4  0.0000000  42.875  15.537
 49   50    1        6      6       6  0.0000000  87.500  17.248
 50   51    1        8      8       8  0.0000000  54.375  47.101
 51   52    1        6      6       6  0.0000000  80.000  43.359
 52   53    1        1      1       1  0.0000000  93.500    .
 53   54    1       13     13      13  0.0000000  59.615  37.219
 54   55    1       26     23      23  0.0629447  63.804  31.604
 55   56    1        3      3       3  0.0000000  60.167   0.289
 56   57    1        2      2       2  0.0000000  45.000  26.284
 57   58    1       10     10      10  0.0000000  44.850  14.944
 58   59    1       21     20      21  0.0050000  60.190  33.191
 59   60    1        4      4       4  0.0000000  56.125  25.516
```

```
OBS TEAM _TYPE_ _FREQ_ NPERCSP NNIOSH MPERCSP  MNIOSH  SNIOSH

 60   61    1      1       1       1   0.100000  75.000    .
 61   62    1     21      20      21   0.004545 117.619  95.425
 62   63    1      2       2       2   0.000000  36.000   6.364
 63   64    1      2       1       1   0.000000  68.500    .
 64   65    1      1       1       1   0.000000  50.000    .
 65   66    1      2       2       2   0.000000  50.000  21.213
 66   67    1      7       4       4   0.025000  83.750  74.764
 67   68    1      1       1       1   0.000000 200.000    .
 68   69    1      5       5       5   0.100000  30.100   8.503
 69   70    1      2       2       2   0.000000  21.000   7.778
 70   71    1      2       2       2   0.000000  49.250  20.153
 71   72    1      1       1       1   0.000000  61.000    .
 72   73    1      1       1       1   0.000000  40.500    .
 73   75    1      2       2       2   0.000000  70.250  48.437
 74   76    1      2       2       2   0.000000 107.500  24.749
 75   77    1      1       1       1   0.000000  22.000    .
 76   78    1      1       1       1   0.000000  45.000    .
 77   79    1      1       1       1   0.800000  26.000    .
 78   80    1      6       1       1   0.000000  56.500    .
 79   81    1      7       1       1   0.000000  70.000    .
 80   82    1      1       1       1   0.000000  20.000    .
 81   84    1     25      25      25   0.010000 148.600 111.528
 82   85    1      5       0       0    .          .        .
 83   86    1      5       0       0    .          .        .
 84   87    1      4       0       0    .          .        .
 85   88    1      2       0       0    .          .        .
 86   89    1      5       5       5   0.220000  69.000  42.190
 87   90    1      2       2       2   0.200000  70.000  21.213
 88   91    1     37      34      36   0.152941  12.944  11.357
 89   92    1     25      24      25   0.079630  58.340  30.542
 90   93    1     18      16      18   0.100000  26.194  13.161
 91   94    1     16      16      18   0.138194  17.667  19.639
 92   95    1     25      25      25   0.187677  63.400  43.642
 93   96    1     36      36      36   0.091582  46.528  23.105
 94   97    1     30      29      30   0.098433  50.783  26.878
 95   98    1     29      27      29   0.161893  13.741   6.968
 96   99    1      9       9       9   0.111111  37.333  24.794
 97  100    1     26      25      26   0.050667  19.135  14.639
 98  101    1      8       7       8   0.128571  22.750  11.991
 99  102    1     27      23      27   0.065217  29.741  13.269
100  103    1     36      36      36   0.013889  31.053  11.849
101  104    1      2       2       2   0.050000   6.000   2.828
102  105    1     28      28      28   0.093831  50.036  36.403
103  106    1     20      20      20   0.000000  27.350  11.185
104  107    1      2       2       2   0.000000  16.250   1.061
105  108    1     23      21      23   0.147619  37.870  26.4[illegible]
106  109    1     22      22      22   0.043182  20.682   8.659
107  110    1     10      10      10   0.232273  21.200  11.942
108  111    1      7       7       7   0.367857  38.143  14.829
109  112    1      4       4       4   0.200000  24.125  25.437
110  113    1      4       4       4   0.025000  16.125  10.570
111  114    1      3       3       3   0.100000  19.333  13.137
112  115    1      1       1       1   0.000000  29.000    .
113  116    1      1       1       1   0.600000  56.500    .
114  117    1      1       1       1   0.000000  40.000    .
115  118    1      2       2       2   0.111111  10.250   3.182
116  119    1      1       1       1   0.000000  15.000    .
117  120    1      3       3       3   0.166667  17.167   2.843
118  121    1      1       1       1   0.500000  14.000    .
```

```
OBS TEAM _TYPE_ _FREQ_ NPERCSP NNIOSH MPERCSP  MNIOSH  SNIOSH

119 122    1       4       4       4   0.270833  43.875 24.3700
120 123    1       3       3       3   0.000000  43.833 17.6942
121 124    1       5       4       5   0.000000  24.900 19.9700
122 125    1       1       1       1   0.000000  32.500   .
123 126    1       1       1       1   0.000000  16.000   .
124 127    1       2       2       2   0.050000  53.000 57.2756
125 128    1       3       3       3   0.133333  19.500 17.3277
126 129    1       2       2       2   0.500000  27.750 32.8805
127 130    1       1       1       1   0.000000  19.500   .
128 131    1       1       1       1   0.000000   5.500   .
129 132    1       1       1       1   0.400000   9.500   .
130 133    1       1       1       1   0.222222   6.500   .
131 134    1       1       1       1   0.500000  74.500   .
132 135    1       2       2       2   0.000000  72.000 26.1630
133 136    1      21      21      21   0.000000  58.738 27.3256
134 137    1       1       1       1   0.000000  89.500   .
135 138    1       2       2       2   0.000000  86.000 18.3848
136 139    1       4       4       4   0.000000  26.875 16.4285
137 142    1       1       1       1   0.000000 120.000   .
138 144    1       1       1       1   0.000000  50.500   .
139 148    1       1       1       1   0.000000  81.000   .
140 149    1      23      23      23   0.000000  84.217 50.3341
141 150    1      23      23      23   0.000000  35.457 18.1113
142 151    1      12      12      12   0.000000  67.125 38.5862
143 152    1      13      13      13   0.000000  64.077 31.6411
144 153    1       7       7       7   0.000000  31.429 16.2466
145 154    1       4       4       4   0.000000  57.875 15.5530
146 155    1      25      25      25   0.012000  56.740 34.1175
147 156    1       5       5       5   0.000000  62.900 13.5368
148 157    1       8       8       8   0.012500  63.500 47.2546
149 158    1       1       1       1   0.000000  48.500   .
150 159    1       7       7       7   0.000000  59.571 45.9261
151 160    1       3       3       3   0.000000  85.667 43.5613
152 161    1       3       3       3   0.000000  56.333 18.1475
153 162    1       2       2       2   0.000000  70.500 11.3137
154 163    1       3       3       3   0.666666  75.667 34.5048
155 164    1       2       2       2   0.000000  47.500 45.2548
156 165    1      27      26      26   0.034615  39.442 22.8584
157 166    1      50      48      48   0.006250  74.542 84.7278
158 167    1      16      16      15   0.000000  37.700 16.8991
159 168    1      25      25      24   0.000000  32.542 14.7898
160 169    1      24      24      24   0.000000  39.792 22.0202
161 170    1      18      18      18   0.000000  35.056 18.0757
162 171    1       1       1       1   0.000000  25.000   .
163 172    1      27      27      27   0.003704  40.963 17.4796
164 173    1      27      27      26   0.000000  51.212 57.5906
165 174    1      22      22      22   0.027273  37.068 14.0155
166 175    1       2       2       2   0.000000  45.250  3.1820
167 176    1      24      24      24   0.009375  48.979 34.9514
168 177    1      21      21      21   0.000000  41.952 21.6025
169 178    1      15      15      14   0.000000  27.286 17.6382
170 179    1       2       2       2   0.000000  29.000  7.0711
171 180    1      23      23      23   0.000000  37.478 17.6162
172 181    1       8       8       8   0.026389  52.188 42.5550
173 182    1       1       1       1   0.000000  41.500   .
174 183    1       3       3       3   0.000000  51.667 22.4072
175 184    1       1       1       1   0.000000  68.500   .
176 185    1       2       0       0    .          .       .
177 186    1       2       1       1   0.333333  60.000   .
```

```
OBS YEAR _TYPE_ _FREQ_ NPENCSP NNIOSH MPENCSP  MNIOSH  SNIOSH

178 187     1       1      1       1  0.000000  10.000    .
179 188     1       1      1       1  0.454545  62.500    .
180 189     1       1      0       0   .          .       .
181 190     1       1      0       0   .          .       .
182 191     1       1      1       1  0.000000 235.000    .
183 192     1       1      1       1  0.000000 170.000    .
184 193     1       3      0       0   .          .       .
185 194     1       1      0       0   .          .       .
186 195     1       1      0       0   .          .       .
187 196     1       1      0       0   .          .       .
188 197     1       1      0       0   .          .       .
189 198     1       1      0       0   .          .       .
190 199     1       1      0       0   .          .       .
191 201     1       2      2       2  0.000000  63.000  1.4142
192 202     1      40     40      40  0.000000  72.862 24.9584
193 203     1      25     25      25  0.000000  93.120 38.0962
194 204     1       6      6       6  0.000000  62.917 26.6372
195 205     1       9      9       9  0.011111  59.167 22.4368
196 206     1       1      1       1  0.000000  23.500    .
197 207     1      10     10      10  0.009091  41.750 20.7448
198 975     1       1      1       1  0.000000 100.000    .
```

Section 4. Health Symptoms

Information on each resident was extracted from the computer tape. Each resident was then classified as to whether he/she had experienced any health symptoms. The average NIOSH in the resident's home was classified as being low (≤.049 ppm), medium (.05 - .099 ppm) or high (≥.10 ppm). In addition, each resident was categorized as being a smoker or non-smoker and whether the resident worked inside or outside the home. The residents were also classified by the average fungal count in the home as low (≤2 counts) and high (>2 counts).

In this section, we are interested in whether there is a dose response relationship between the NIOSH levels and the percentage of residents with particular health symptoms. If NIOSH is related to health problems, we should see an increase in the percentage of health symptoms as the NIOSH levels increase. Likewise, if fungal counts are related to health problems, we should see a similar increase. Classifications were done for both smokers and non-smokers and for residents working inside or outside the home. It was felt that it was important to distinguish between smoking status as well as work location because of the potentially different responses to increased UFFI or fungal levels in the home.

Table 4.1 shows the percentage of residents with health symptoms classified by NIOSH class and smoking status. The percentage of residents with symptoms in each NIOSH class appears to be relatively constant, with many categories even

TABLE 4.1

Percentage of Residents with Health Symptons Classified by Average Niosh Class and Smoking

Symptom	Smoking Status	Average Niosh ≤.049	.05-.099	≥.10
Skin Irritation	Smokers	12.4	6.7	14.3
	Non-Smokers	8.8	6.9	5.2
Colds	Smokers	30.3	24.3	29.6
	Non-Smokers	24.4	21.5	22.4
Burning	Smokers	20.4	14.1	18.4
	Non-Smokers	14.4	11.2	7.1
Eye Irritation	Smokers	22.4	16.8	21.4
	Non-Smokers	16.3	13.0	11.5
Sleeplessness	Smokers	12.8	7.5	9.2
	Non-Smokers	8.2	6.6	5.7
Fatigue	Smokers	18.5	14.9	15.3
	Non-Smokers	11.6	9.2	9.3
Nose	Smokers	7.1	4.5	6.1
	Non-Smokers	6.8	4.8	6.8
Head	Smokers	12.1	16.8	17.4
	Non-Smokers	14.4	15.0	12.0
Nausea	Smokers	6.7	4.5	4.1
	Non-Smokers	4.4	3.9	3.8
Dizziness	Smokers	9.9	7.7	9.2
	Non-Smokers	5.3	5.3	3.6
Physician Consulted	Smokers	18.3	16.0	14.3
	Non-Smokers	15.0	15.9	13.7

showing an apparent decrease in the percentage of residents with symptoms. This trend is similar for both smokers and non-smokers. We do notice an apparent jump in the reported incidence of symptoms for smokers as compared to non-smokers; but it would appear that the NIOSH is not a factor in this.

Table 4.2 is the same classification as Table 4.1 except that work status (inside or outside the home) replaces smoking status. Again, we see an apparent lack of a dose responce relationship between NIOSH class and health symptoms. A puzzling feature of this table however, is the increase in the percentage of symptoms in the inside group as compared to the outside group. This might possibly be related to sex differences, in that inside workers are predominantly female and outside workers male.

Table 4.3 shows the percentage of residents with health symptoms classified by fungal count and smoking status. As in previous tables, no apparent relationship is present between fungal count and symptoms.

Table 4.4 is the same as Table 4.3 except smoking status is replaced by work status. In this table, there is an apparent increase in sleep and fatigue problems for the inside group, as the fungal count increases. The other symptoms seem generally unrelated.

In all of these tables, there is one statistical problem which makes interpretation a problem. This is the lack of independence between individuals. Since a family of residents all come from the same home with the same NIOSH levels, the residents can not be considered as completely independent.

This problem violates certain statistical assumptions and as a result, assertions based on these tables should not be made too strongly.

The tables dealing with NIOSH class all had very large numbers of observations (5619 in total) and as a result no mention of the actual frequency made. The tables dealing with fungal counts however, have much fewer observations and thus the actual number of observations on which the percentages are based are shown in brackets.

These analyses were repeated excluding the maritime provinces. However, no differences were apparent between the two sets of analyses.

TABLE 4.2

Percentage of Residents with Health Symptons Classified by Average Niosh and Work Inside or Outside Home

Symptom	Work Status	Average Niosh ≤.049	.05-.099	≥.10
Skin Irritation	Inside	10.5	8.9	9.6
	Outside	8.7	5.4	5.3
Colds	Inside	29.5	24.5	31.3
	Outside	22.3	20.4	18.4
Burning	Inside	20.1	15.8	13.1
	Outside	11.8	9.0	6.8
Eye Irritation	Inside	21.5	16.9	19.2
	Outside	14.3	11.9	9.4
Sleeplessness	Inside	11.7	8.8	8.6
	Outside	7.0	5.4	4.9
Fatigue	Inside	15.1	11.6	12.6
	Outside	11.3	9.5	9.0
Nose	Inside	6.8	4.2	6.6
	Outside	7.0	5.2	6.8
Head	Inside	18.5	17.2	16.7
	Outside	13.5	14.1	10.5
Nausea	Inside	6.3	3.9	5.1
	Outside	3.7	4.1	3.0
Dizziness	Inside	8.9	8.5	6.1
	Outside	3.9	3.8	3.8
Physician Consulted	Inside	20.6	19.5	21.7
	Outside	11.6	13.3	7.9

TABLE 4.3

Percentage of Residents with Health Symptoms Classified by Average Fungal Count and Smoking Status

Symptom	Smoking Status	Average Fungal Count	
		≤2	>2
Skin Irritation	Smoker (S)	23.8 (5/21)	12.2 (5/41)
	Non-Smoker (NS)	11.9 (15/126)	9.3 (9/97)
Colds	S	23.8 (5/21)	17.1 (7/41)
	NS	27.7 (35/126)	26.8 (26/97)
Burning	S	57.1 (12/21)	7.3 (3/41)
	NS	17.5 (22/126)	15.5 (15.97)
Eye Irritation	S	42.9 (9/21)	19.5 (8/41)
	NS	22.2 (28.126)	17.5 (17/97)
Sleeplessness	S	14.3 (3/21)	9.8 (4/41)
	NS	11.9 (15/126)	13.4 (13/97)
Fatigue	S	19.1 (4/21)	19.5 (8/41)
	NS	10.3 (13/126)	19.6 (19/97)
Nose	S	9.5 (2/21)	7.3 (3/41)
	NS	4.8 (6/126)	4.1 (4/97)
Headache	S	38.1 (8/21)	12.2 (5/41)
	NS	19.8 (25/126)	12.4 (12/97)
Nausea	S	4.8 (1/21)	4.9 (2/41)
	NS	4.0 (5/126)	3.1 (3/97)
Dizziness	S	19.1 (4/21)	12.2 (5/41)
	NS	7.1 (9/126)	10.3 (10.97)
Physician Consulted	S	14.3 (3/21)	12.2 (5/41)
	NS	20.6 (26/126)	18.6 (18/97)

(Numerator/Denominator) which gave percentage are shown in brackets.

TABLE 4.4

Percentage of Residents with Health Symptoms Classified by Average Fungal Count and Working Inside and Outside Home

Symptom	Work Status	Average Fungal Count ≤2	>2
Skin Irritation	Inside (I)	13.5(10/74)	10.8(7/65)
	Outside (O)	13.7(10/73)	9.6(7/73)
Colds	I	31.1(23/74)	36.9(24/65)
	O	23.3(17/73)	12.3(9/73)
Burning	I	29.7(22/74)	18.5(12/65)
	O	16.4(12/73)	8.2(6/73)
Eye Irritation	I	27.0(20/74)	26.2(17/65)
	O	23.3(17/73)	11.0(8/73)
Sleeplessness	I	10.8(8/74)	21.5(14/65)
	O	13.7(10/73)	4.1(3/73)
Fatigue	I	13.5(10/74)	29.2(19/65)
	O	9.6(7/73)	11.0(8/73)
Nose	I	5.4(4/74)	9.2(6/65)
	O	5.5(4/73)	1.4(1/73)
Headache	I	29.7(22/74)	18.5(12/65)
	O	15.1(11/73)	6.9(5/73)
Nausea	I	6.8(5/75)	7.7(5/65)
	O	1.4(1/73)	0.0(0/73)
Dizziness	I	14.9(11/74)	15.4(10/65)
	O	2.7(2/73)	6.9(5/73)
Physician Consulted	I	25.7(19/74)	29.2(19/65)
	O	13.7(10/73)	5.5(4/73)

(Numerator/Denominator) which gave percentages are shown in brackets.

APPENDIX 1

Analysis Label	Description	How Defined
Age	Age of Home	1 - 5
Air Cond	Air Conditioning	0 = No 1 = Yes
Avdraeg	Average Draeger Reading	PPM
BBN	Max NIOSH Greater than 100 (ppb)	0 = ≤100 ppb 1 = >100 ppb
BETBW	UFFI installed between brick walls	0 = not installed 1 = installed
BETSBW	UFFI installed between sheathing and Brick walls	0 = not installed 1 = installed
BN	Average NIOSH greater than 100 (ppb)	0 = <100 ppb 1 = ≥100 ppb
Contract	Name of Contractor	3 digit code
CUFFI	Class of UFFI	0 = A, B, or C 1 = D or E
Damage	Accidental Damage to UFFI Cavity	0 = Yes 1 = No
DE	Walls with D or E class of UFFI	0 = none 1 = at least one
DIFFHUM	Humidity Gradient (Inside-Outside)	% Relative
DIFFTEMP	Thermal Gradient (Inside-Outside)	°C
E	Walls with Class of UFFI E	0 = none 1 = at least one wa
EUFFI		
EXHUMID	External Humidity	% Relative Humidit
EXTEMP	External Temperature	°C
FIREPL	number of fireplaces	0 - 6
G	Group	1 = control 2 = UFFI installed

Analysis Label	Description	How Defined
Group 1	Actual Study Group	1 = Control 2 = first one hundred homes 3 = UFFI homes from ICC 4 = homes from CHIP 5 = N.R. retests
Heating	Heating System	0 = hot air 1 = other
House	ICC REF House No.	
Installer	Who installed?	0 = homeowner 1 = contractor
Inhumid	Internal Humidity	% Relative
Intake	External air intake on furnace	0 = Yes 1 = No
INTEMP	Internal Temperature	°C
MANUFACT	Manufacturer	1 = Borden 2 = Rapco 3 = Comtec 4 = Canada Foam 5 = Reichold 6 = ? 7 = Energlobe 8 = Publix 9 = Other
MAXDRAEG	Maximum Draeger Reading	ppm
MAXNIOSH	Maximum NIOSH Reading	ppb
MOISTBAR	Moisture Barrier	0 = Yes 1 = No
NIOSH	Average Internal NIOSH Reading	ppb
Odour	Odours present and not outside?	1 = No 2 = Yes
OTHUFFI	UFFI installed other than BETBW, STUDSP, BETSBW	0 = not installed 1 = installed
Percent	Percent of exterior walls with UFFI	ppb

Analysis Label	Description	How Defined
PERCSP	Proportion of spoiled Draeger Readings within a home	0 - 1.0
PROV	Province	
STUDSP	UFFI installed in Studspace	0 = not installed 1 = installed
UAGE	Age of UFFI	months
VAP	Average Water Vapour in cavity	mg/
WALL COND	Wall Condition	1 = no leakage 2 = some 3 = many obvious
WINDSP	Wind Speed	km/hr
WM	Average Wood Moisture in cavity	%

APPENDIX 2

Explanation of Regression Output:

Table 2.A is an example of a typical regression output listing in which sections are numbered from 1 to 5.

Section 1 is simply a title for this particular analysis.

Section 2 names the dependent or predicted variable.

Section 3. This section shows an analysis of variance table used to assess the overall significance of the regression model. Under the heading source, there are three lines labelled model, error and total. These lines reflect the fact that variation among the NIOSH readings can be split up into two components--variation attributable to the regression model and variation which is left over or error. Mathematically this is:

$$\text{Total NIOSH Variation} = \text{Model Variation} + \text{Error Variation}$$

Across each line in this section we see the values associated with the source of variation for that particular line.

DF or Degrees of Freedom for the model is equal to the number of independent variables in the model. Total DF is simply the total number of observations minus 1. In section 3, the two values of primary interest are the F value and the prob>F. The F value represents the ratio of average deviation of the regression model to average random deviation. If the model does not account for any more than random variation, the F will equal 1. As F increases, the model is accounting for more and more variation relative to error. As a result, we would like to see a large value of F associated with the model.

The Prob>F value represents the probability that the null hypothesis for the regression analysis is true. The null hypothesis in our analysis is that there is no relationship between the dependent variable and any of the independent variables. Low probability values (conventionally those $\leq .05$) cause us to reject the null hypothesis in favour of the alternate hypothesis--that there is a relationship. High values ($>.05$) tend to support the null hypothesis.

Section 4. In this section, the R-square value is mainly of interest. This value is a measure of the proportion of variation in the dependent variable which can be explained or attributable to the regression model. R-square can be expressed as a percentage and in this example we would say that 15% of the variation in NIOSH levels can be attributed to the factors in our regression model.

The R-square value is not always a reliable indication of the adequacy of the regression model. Since measurement variation can, and in this case does, outweigh variation attributable to the independent or predictor variables. As a result, we may get low values for R-square yet still find some variables to be highly significant predictors.

Section 5. This section gives the parameter estimates for the regression model. In this example, our estimated regression equation would be

$$\begin{aligned} \text{NIOSH} = 74.98 &+ 1.37\ (\text{INTEMP}) \\ &-.72\ (\text{EXTEMP}) \\ &-.99\ (\text{INHUMID}) \\ &+.08\ (\text{EXHUMID}) \\ &+.05\ (\text{PERCENT}) \\ &-.18\ (\text{UAGE}) \\ &-2.62\ (\text{WALLCOND}) \\ &-5.64\ (\text{DAMAGE}) \\ &-1.31\ (\text{WM}) \\ &+4.65\ (\text{VAP}) \\ &+.99\ (\text{AVDRAEG}) \end{aligned}$$

The standard error column lists the average variation associated with each parameter estimate.

The T values are similar to the F values in section 3 and are a measure of how different the parameter estimate is from zero. If the parameter was not significantly different from zero, then we can infer that the dependent variable is not significantly related to that particular variable. Likewise, the Prob>|T| value represents the probability that we have observed such an unusual value of the estimate if the underlying parameter is, in fact, zero. Thus, small probabilities imply that there is a relationship between the dependent and that particular independent variable.

```
1 NIOSH VERSUS ALL BETBW=1 BARITIMES OUT

2 DEP VARIABLE: NIOSH

                       SUM OF            MEAN
3 SOURCE     DF       SQUARES          SQUARE         F VALUE        PROB>F

  MODEL      11     19819.742        1801.795           1.433        0.1663
  ERROR      88        110652        1257.408
  C TOTAL    99        130472

4     ROOT MSE      35.459356        R-SQUARE          0.1519
      DEP MEAN      50.275000        ADJ R-SQ          0.0459
      C.V.           70.53199


                    PARAMETER        STANDARD    T FOR H0:
5 VARIABLE   DF      ESTIMATE           ERROR  PARAMETER=0     PROB > |T|

  INTERCEP    1     74.984664       77.767586        0.964         0.3376
  INTEMP      1      1.370505        2.757639        0.497         0.6204
  EXTEMP      1     -0.721022        1.144729       -0.630         0.5304
  INHUMID     1     -0.997136        0.419202       -2.379         0.0195
  EXHUMID     1      0.080727        0.270931        0.298         0.7664
  PERCENT     1      0.045896        0.146585        0.320         0.7498
  UAGE        1     -0.178908        0.368567       -0.485         0.6286
  WALLCOND    1     -2.620899        5.207246       -0.503         0.6160
  DAMAGE      1     -5.638243        9.669107       -0.583         0.5613
  WM          1     -1.313217        2.443374       -0.537         0.5923
  VAP         1      4.646894        2.333604        1.991         0.0495
  AVDRAEG     1      0.986650        1.572213        0.628         0.5319
```

Table 2.A

Number/
Numéro

6

Annexe 6

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UFFI REFERENCE CENTRE
CENTRE DE DOCUMENTATION
DE LA MIUF

UFFI NATIONAL TESTING PROGRAM

QA/QC FINAL REPORT

Submitted to:

Department of Consumer and Corporate Affairs

Prepared by:

Concord Scientific Corporation

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February 1982

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INTRODUCTION

Concord Scientific Corporation conducted an external quality assurance program for and directed the internal quality control program of the members of the national testing program consortium. The programs were based on the Technical Procedures Manual and The Quality Assurance/ Quality Control Specifications developed (in part) by Concord Scientific for the testing program.

These procedures and specifications were modified to accommodate a six-week program. The modified QA/QC approach is described briefly in the following chapters, which present the results of the QA/QC program.

1. SUMMARY OF FIELD AND LABORATORY AUDITS

Concord Scientific staff visited all participating laboratories in the national testing consortium to evaluate their analytical technique. Field teams conducted unannounced audits on 25 technician teams across the country (about 45% of the consortium's operating teams) and carried out parallel (replicate) sampling beside 20 of these teams.

1.1 Field Team Audits

The purpose of the field team audits was to provide a measure of quality assurance and quality control to the performance of the home surveys by the field sampling teams. Individual teams were observed by a quality control person as they conducted the specified sampling procedures in a home. In addition, side-by-side replicate sampling was done on the sampling team's room air samples for formaldehyde (NIOSH-revised method) by the quality control person.

Detailed observations of individual sampling teams were made in twenty-five (25) homes, and may be found in Appendix A. Replicate sampling was conducted in twenty (20) homes. Summaries of the observations made and the replicate sampling results are outlined in the following sections.

1.1.1. Observations

Field sampling teams were observed and questioned during their survey work, to assess the following:

(1) Their knowledge and application of the specified sampling procedures;

(2) Their sampling media storage methods, sample transfer techniques, and sample shipping procedures;

(3) The calibration of their sampling equipment;

(4) The reliability of their sampling trains;

(5) Their observations of and solutions to problems encountered in the field; and

(6) Their overall care in the work.

The procedures and equipment used by the field sampling teams showed regional variations, resulting from regional staffing procedures (field team educational levels), their project-specific training, and the proximity and procedures of the support laboratory in each area. There were, in addition, team variations within each region, resulting from variations in equipment performance, and from the degree of understanding of the individuals involved. Factors observed by the quality control persons which contributed significantly to potential error are discussed below.

Calibration of Sampling Train

In the eastern provinces the initial calibration of flow regulating or measuring devices, generally rotameter, was performed using other than a primary standard. As a result, most of the rotameters used in the field were in effect tertiary standards. This, along with other problems, delineated below under "Use of Rotameters" led to the high error in sampling.

Wall Cavity Formaldehyde - Use of Drager Sampling Equipment

Three general areas involving the misuse of Drager equipment for wall cavity sampling were noted.

The first and most significant was that certain field team members were not breaking the inner vial containing the xylene necessary for colour development. As result all values recorded were less than 0.5 ppm.

The second major problem is that samples were taken in the wrong wall space. This occurred mainly in houses with brick siding.

The third problem was that certain team members rushed the pumping sequence and in doing so did not allow the proper volume to pass through the sampling tube.

Use of Rotameters

The typical field sampling train consisted of an AC pump (usually Cole Parmer Model #7530-40, or equivalent by Gast or Lamotte), a rotameter valve to control the flow rate (Lab Crest Century, Matheson, or Alborg), and an impinger (glass or polypropylene). In several cases, battery-operated pumps with either built-in rotameters (for example, Mine Safety Appliances personal sampling pump) or constant flow capability (Dupont Model P2500) were used with impingers. In a few cases, valves external to the rotameter were put in the sampling line for improved flow control.

The rotameters were individually calibrated in a typical sampling train at the beginning of the project. The rotameter set points for a flow rate of one litre per minute (1 Lpm) were noted on the side of each rotameter. They were then used interchangeably in the field. Recalibration was generally infrequent, and related to the proximity of the support laboratory.

During field sampling, each rotameter was usually placed between impinger and pump (in one region, the rotameter was placed in front of the impinger in the sampling train). The flow rate through each impinger was set by adjusting the rotameter to its set point after the sampling pump was turned on. In most cases observed, each rotameter was readjusted to its original set point approximately ten minutes later, because of flow variations caused by the pump's warming up.

Rotameter checks and adjustments made by the sampling teams during the remaining portion of the sampling period were generally infrequent. In several cases, this was because of rotameter/flow control valve assembly had proven performance of negligible variation. In most cases, however, infrequent adjustments were made because their importance in maintaining a constant flow rate was not realized. Flow variations of 10% (average) and 25% (maximum) were frequently observed during the sampling period by the quality control person. The variations were usually decreases in flow.

Therefore, an error in sample volume was introduced as a result of infrequent rotameter adjustment.

It was also observed by the quality control person that sample flow rates at the calibrated rotameter set points were significantly different (>± 0.1 Lpm) in 30% of the cases. Therefore, an additional error in sample volume was introduced as a result of infrequent rotameter recalibration.

Condensation In Rotameters

No drying tubes were used in each sampling train between the impinger and rotameter. As a result, water vapour carried by the sampling stream gradually condensed and accumulated in the rotameters. (In the case of the constant flow Dupont pumps, the water vapour affected the operation of the flow sensor.) Its effect was to act as a seal around the rotameter ball, significantly decreasing the airflow through the rotameter for any given set point.

The extent to which this problem affected the sample volume is difficult to estimate. Several field teams observed condensation in their rotameters; one handled the problem by drying the rotameters each night with a warm air stream; most had not recognized that the condensation in rotameters was a problem.

1.1.2. Replicate Sampling Results

Concord Scientific Corporation in addition to its other duties as QA/QC contractor performed side-by-side sampling with twenty field teams. The twenty field teams were picked at random from across the country and included representives of all companies except Warnock-Hersey and Proctor and Redfern.

The results obtained are listed on the next page as Table 1.1.2. The values listed in the column headed $CV_{(S+P)}$ were used to calculate the $CV_{(S+P)}$ value explained in chapter four of this report.

The explanation for many of the exceptionally high (low) $CV_{(S+P)}$ values can be traced generally to the high CV_p component indicating great variability in pump rates.

A Student's t-test was performed on the pairs of results in the second and third columns of the table. The results were as follows.

$\overline{\Delta}$ = 0.0033 ppm

S = 0.034 7 ppm

$S_{\overline{\Delta}} = {}^{S}/\sqrt{N} = 0.0347/6.6 = 0.0053$

$t = |\overline{\Delta}| / S_{\overline{\Delta}} = 0.0033/0.0053 = 0.63$

$t^{1}_{0.01,44} = 2.69$,

therefore, the mean difference between the pairs of results is not significantly different from zero. Although this indicates that there is no systematic difference between Concord's result and the others' results, the large standard deviation indicates that the random errors are substantial.

1.1.2 REPLICATE SAMPLING RESULTS

LABORATORY & SAMPLE TEAM	CSC RESULTS (ppm)	THEIR RESULTS (ppm)	MEAN	STANDARD DEVIATION	CV_T	CV_A	$CV_{(S+P)}$
Geortech	0.062	0.091	0.0765	0.021	0.275	0.21	0.17
Snow & McLagen	0.062	0.067	0.0645	0.004	0.062	0.22	-0.21
Technitrol	0.004	0.019	0.0115	0.011	0.957	0.68	0.67
Thomas,Rothwell &	0.051	0.046	0.0485	0.004	0.082	0.28	-0.26
Cahill	0.063	0.044	0.0535	0.013	0.243	0.27	-0.12
MacLaren, N.S.	0.001	<0.018					
Henderson & Ross	0.039	0.090	0.0645	0.036	0.558	0.24	0.50
	0.038	0.094	0.066	0.040	0.606	0.24	0.46
MacLaren, N.S.	0.003	0.018	0.010	0.011	1.10	0.75	0.81
Waite & Barkhouse	0.035	0.060	0.0475	0.018	0.379	0.28	0.26
	0.047	0.091	0.069	0.031	0.449	0.22	0.39
Technitrol	0.094	0.037	0.0655	0.040	0.610	0.24	0.56
M & Mme Gaston	0.098	0.052	0.075	0.033	0.440	0.21	0.39
Technitrol	0.077	0.017	0.047	0.042	0.894	0.28	0.85
	0.086	0.044	0.065	0.030	0.462	0.24	0.39
Atlantic Analytical	0.018	NR					
Pelletier & Morrison	0.043	0.008	0.0255	0.025	0.980	0.44	0.88
	0.028	NR					
Scanada	0.0	<0.01					
Ruest & Fortier	0.042	0.03	0.036	0.008	0.222	0.35	-0.27
	0.140	0.05	0.095	0.064	0.674	0.17	-0.27
Levelton	0.026	0.030	0.028	0.003	0.674	0.38	0.56
MacLean	0.059	0.025	0.042	0.024	0.571	0.32	0.47
Atlantic Analytical	0.045	0.034	0.0395	0.008	0.203	0.34	-0.27
Nagle & Morrison	0.079	0.174	0.1265	0.067	0.529	0.15	0.51
Scanada	0.069	0.05	0.0595	0.013	0.218	0.24	-0.10
Sansom & Rockley	0.081	0.09	0.0855	0.006	0.070	0.18	-0.17
MacLaren N.S.	0.022	0.069	0.0455	0.033	0.725	0.31	0.66
Perry & Donahue	0.028	0.047	0.0375	0.013	0.347	0.35	0.0
Technitrol	0.031	0.067	0.049	0.025	0.510	0.28	0.43
Gallagher & Lakhani	0.041	0.035	0.038	0.004	0.105	0.35	-0.30
Levelton	0.041	0.019	0.030	0.016	0.533	0.40	0.35
Jung	0.025	0.008	0.016	0.012	0.750	0.62	0.42
Levelton	0.043	0.042	0.043	0.001	0.023	0.32	-0.32
McVicar	0.045	0.0429	0.044	0.001	0.023	0.32	-0.32
Levelton	0.100	0.0521	0.076	0.034	0.447	0.21	0.39
Bilbey	0.063	0.0508	0.057	0.009	0.158	6.27	-0.22
Levelton	0.032	0.022	0.027	0.007	0.259	0.44	-0.36
MacKay	0.025	0.013	0.029	0.008	0.421	0.62	-0.46
Levelton	0.079	0.049	0.064	0.021	0.328	0.24	0.22
Quigley	0.076	0.041	0.059	0.025	0.424	0.24	0.34
	0.083	0.066	0.075	0.012	0.160	0.21	-0.14
MacLaren, Ont.	0.010	0.019	0.075	0.012	0.160	0.21	-0.14
Cosburn & Rockel	0.047	0.088	0.068	0.029	0.426	0.23	0.36
	0.061	0.057	0.059	0.003	0.051	0.24	-0.23
Technitrol	0.053	0.026	0.039	0.019	0.487	0.35	0.34
Markell & Racine	0.008	0.014	0.017	0.013	0.765	0.62	-0.45

1.2 Laboratory Inspections

Eight laboratory inspections were carried out during the course of the national testing program. The following table indicates the dates of inspection and the person performing the inspection:

LAB	INSPECTION	DATE (1981)
Enviroclean (MacLaren)	J.E. Lux	October 7
Technitrol	J.E. Lux	October 8
MacLaren (Dartmouth)	J.G. Stevens	October 14
Geortec	J.G. Stevens	October 16
Atlantic Analytical Servs.	J.G. Stevens	October 19
Levelton	J.E. Lux	October 19
Proctor & Redfern	J.E. Lux	October 27
Warnock Hersey	S.G. Guerin	October 28

1.2.1 Observations

There were few problems observed during the site vists, and those were generally easily remediable. The inspectors' comments are given in Appendix A.

The common deficiencies were:

1. inadequate storage containers, refrigeration, etc., or dating of reagent solutions;
2. lack of awareness of potential contamination problems (smoking, general cleanliness, etc.);
3. insufficient attention to purity of reagent water.

2. SUMMARY OF COLLABORATIVE TEST RESULTS

The collaborative study was performed according to the standard AOAC procedure. Concord Scientific sent standard samples to all labs in the national testing consortium. The samples were formaldehyde of a known concentration in 1% sodium bisulfite.

The first round consisted of six samples. There were two samples in each range, high, medium and low. One bottle of each was used for duplicate analysis on Day 1. The second bottle was analysed once on Day 2. The normal revised NIOSH procedure was used.

The second round of collaborative tests consisted of six samples, two ultra low, two very low and two low range. The third round also consisted of six samples but these were in the very low range and in the low range.

The results are presented in Appendix B (i). The statistical treatment of the collaborative test results follows.

The standard samples for sets A, B and D were made up from crystalline sodium formaldehyde bisulphite (Eastman Kodak) standard. Set C was made up from a solution of refluxed paraformaldehyde that had been standardized by the procedure of sodium sulphite addition and potentiometric back-titration.

Outline of Procedure

Details of the procedures used may be found in the Statistical Manual of the Association of Official Analytical Chemists (AOAC). The bulk of the statistical analysis was carried out on the data set consisting of single analytical values reported for the 'Day 2' exercise in Round 1 and all of the (single) values reported in Rounds 2 and 3. The additional (duplicated) values from 'Day 1' of Round 1 were not used because of the artificial reduction in variation that would have resulted from averaging the duplicate pairs. That is, analysis of single results leads to a more accurate picture of the uncertainty of an isolated, single measurement.

The basic reason for treating the sums and differences of pairs of results for closely grouped nominal or accepted, standard samples in the statistical analysis is that the sums will contain both random (precision) variation and systematic (accuracy or bias) variation; whereas the differences contain only random variation. Thus, the two sources of variance can be resolved and quantified.

A summary of the interpretation of the statistics follows the tables of results.

COLLABORATIVE TESTING

The following laboratories participated in the three-phased Collaborative study:

Laboratory	Designation
Concord Scientific Corporation	A
Levelton	B
Technitrol	C
Enviroclean	D
Geortech	E
Atlantic Analytical	F
Proctor & Redfern	G
Warnock Hersey	H
MacLaren Plan Search (N.S.)	I*

*did not report results for second and third rounds.

Tests in the following ranges were:

ultra low	< 0.100 ug/ml
very low	< 0.150
low	< 0.5
mid	< 1.500
high	> 1.500

First Round Collaborative Testing - Averaging All Values (A and B Samples)

Low Range (Combined) but not adjusted

Nominal Value $X = 0.22$, $Y = 0.49$

Laboratory	A	B	C	D	E	F	G	H	I
Sample X	0.19	0.13	0.13	0.26	0.20	0.14	0.19	0.17	0.18
Sample Y	0.48	0.37	0.44	0.56	0.49	0.42	0.48	0.46	0.58
Differences Y-X	0.29	0.24	0.31	0.30	0.29	0.28	0.29	0.29	0.40
Totals Y+X	0.67	0.50	0.57	0.82	0.69	0.56	0.67	0.63	0.76

$\bar{X}_D = 0.299$

$S_D = 0.043$

$S_r = 0.030$ (Precision)

$$S_D = \sqrt{\frac{\Sigma(D_i - \bar{D})^2}{n-1}}$$

$$S_r = \sqrt{\frac{\Sigma(D_i - \bar{D})^2}{2(n-1)}}$$

$$S_d = \sqrt{\frac{\Sigma(T_i - \bar{T})^2}{2(n-1)}}$$

$\bar{X}_T = 0.65$

$S_d = 0.07$

$$F = \frac{S_d^{\,2}}{S_r^{\,2}} = \frac{0.0049}{0.0009} = 5.4$$

at 95 % confidence $F = 3.44$ $(n-1 = 8)$

$\therefore$ systematic errors

$S_b^{\,2} = 0.002$ $S_b = 0.045$

$$CV_A = \frac{Sd}{-} = \frac{0.07}{0.36} = 20$$

First Round Collaborative Test (A and B samples)

Low Range Nominal Values X - 0.22 Y - 0.49

Laboratory	A	B	C	D	E	F	G	H	I
Sample X	0.23	0.12	0.07	0.23	0.22	0.15	0.18	0.21	0.17
Sample Y	0.48	0.42	0.40	0.53	0.52	0.42	0.45	0.47	0.59
Difference Y-X	0.25	0.30	0.33	0.30	0.30	0.27	0.27	0.26	0.42
Totals X+Y	0.71	0.54	0.47	0.76	0.74	0.67	0.63	0.68	0.76

$\bar{X}_D = 0.30$ $S_D = 0.051$ $S_r = 0.036$ (Precision)

$\bar{X}_T = 0.66$ $S_d = 0.071$

$$F = \frac{S_d^2}{S_r^2} = \frac{0.0050}{0.0013} = 3.846 \quad (F \text{ at } 95\ \% = 3.44)$$

$\therefore$ Significant Systematic errors

$S_b^2 = 0.0019$

$S_b = 0.044$

$$CV_A = \frac{0.071}{0.36} = 0.20$$

First Round Collaborative Test (A and B samples)

Mid-Range Nominal Values X - 1.12 Y - 1.46

Laboratory	A	B	C	D	E	F	G	H	I
Sample X	1.11	0.99	1.05	1.23	1.16	1.02	1.11	1.10	1.15
Sample Y	1.41	1.38	1.13	1.72	1.40	1.36	1.48	1.47	1.58
Difference Y-X	0.30	0.39	0.08	0.49	0.24	0.34	0.37	0.37	0.43
Total X+Y	2.52	2.37	2.18	2.95	2.56	2.38	2.59	2.57	2.73

$\bar{X}_D = 0.33$ $S_D = 0.119$ $S_r = 0.084$

$\bar{X}_T = 2.54$ $S_d = 0.157$

$$F = \frac{S_d^2}{S_r^2} = \frac{0.0246}{0.007} = 3.51$$

(at 95 % with 8 degrees of freedom F = 3.44)

∴ Significant systematic error

$S_b^2 = 0.009$

$S_b = 0.095$

$$CV_A = \frac{0.157}{1.29} = 0.12$$

First Round Collaborative Study (A and B samples)

High Range Nominal Values $X = 2.02$ $Y = 2.24$ μg/ml

Laboratory	A	B	C	D	E	F	G	H	I
Sample X	1.91	1.93	2.17	1.78	2.04	2.04	2.00	1.97	2.11
Sample Y	1.97	2.12	2.40	2.38	2.22	2.19	2.26	2.18	2.40
Difference X-Y	0.06	0.19	0.23	0.60	0.18	0.15	0.26	0.21	0.29
Total X+Y	3.88	4.05	4.57	4.16	4.26	4.23	4.26	4.15	4.51

$\bar{X}_D = 0.24$ $S_D = 0.150$ $S_r = 0.106$

$\bar{X}_T = 4.23$ $S_d = 0.150$

$$F = \frac{S_d^2}{S_r^2} = \frac{0.0225}{0.0112} = 2.01$$

∴ No significant systematic error

$S_b^2 = 0.0056$

$S_b = 0.075$

$$CV_A = \frac{0.150}{2.13} = 0.07$$

SECOND ROUND COLLABORATIVE TEST (C samples)

Ultra Low Range: Nominal Values $X = 0.038$; $y = 0.076$

LABORATORY	A	B	C	D	E	F	G	H	I
SAMPLE X	0.033	0.02	0.00	0.0	0.023	0.00	0.06	0.036	-
SAMPLE Y	0.025	0.096	0.036	0.04	0.038	0.035	0.17	0.064	-
DIFFERENCES Y - X	(-0.008)	0.076	0.036	0.04	0.015	0.035	0.11	0.028	-
TOTAL Y + X	0.058	0.116	0.036	0.04	0.061	0.035	0.23	0.100	-

$\bar{X}_D = 0.044$ $S_D = 0.034$ $S_r = 0.024$

$\bar{X}_T = 0.085$ $S_d = 0.046$ $CV_d = \frac{0.046}{0.057} = 0.81$

$F = \frac{S_d^2}{S_r^2} = \frac{0.0021}{.0006} = 3.67$ F = 3.75 at 95 % confidence level and $(n-1) = 7$.

Therefore no significant systematic error.

$S_b = 0.027$

$CV_A = \frac{0.046}{0.057} = 0.81$

SECOND ROUND COLLABORATIVE TEST (C samples)

Very Low Range: Nominal Value X = 0.114 Y = 0.152

LABORATORY	A	B	C	D	E	F	G	H	I
SAMPLE X	0.105	0.104	0.078	0.140	0.075	0.060	0.21	0.083	-
SAMPLE Y	0.152	0.116	0.138	0.198	0.166	0.133	0.22	0.140	-
DIFFERENCE Y - X	0.047	0.012	0.060	0.058	0.091	0.073	(-0.01)	0.067	-
TOTALS Y + X	0.257	0.220	0.216	0.338	0.241	0.193	0.43	0.223	-

$\bar{X}_D = 0.052$ $S_D = 0.028$ $S_r = 0.019$

$\bar{X}_T = 0.261$ $S_d = 0.058$ $CV_d = \frac{0.058}{.133} = 0.44$

F = 9.31 therefore significant systematic error

$S_b = 0.038$

$CV_A = \frac{0.058}{0.133} = 0.44$

SECOND ROUND COLLABORATIVE TEST (C samples)

Low Range: Nominal Values $X = 0.190$ $Y = 0.227$

LABORATORY	A	B	C	D	E	F	G	H	I
SAMPLE X	0.195	0.136	0.171	0.229	0.181	0.170	0.27	0.170	-
SAMPLE Y	0.214	0.196	0.223	0.259	0.264	0.280	0.31	0.210	-
DIFFERENCE Y - X	0.019	0.060	0.052	0.030	0.083	0.110	0.04	0.040	-
TOTALS Y + X	0.409	0.332	0.394	0.488	0.445	0.450	0.58	0.38	-

$\bar{X}_D = 0.054$ $S_D = 0.029$ $S_r = 0.021$

$\bar{X}_T = 0.435$ $S_d = 0.054$ $F = \frac{0.0029}{0.0004} = 7.25$ Therefore significant systematic error

$CV_d = \frac{0.054}{0.208} = 0.26$ $S_b^2 = 0.0012$ $S_b = 0.035$

$CV_A = \frac{0.054}{0.21} = 0.26$

THIRD ROUND COLLABORATIVE TEST (D samples)

Very Low Range: Nominal Value $X = 0.054$ $Y = 0.119$

LABORATORY	A	B	C	D	E	F	G	H	I
SAMPLE X	0.02	0.016	0.0	0.036	0.015	0.10	<0.01	0.024	-
SAMPLE Y	0.148	0.034	0.118	0.113	0.129	0.11	.06	0.110	-
DIFFERENCE Y - X	0.146	0.068	0.118	0.077	0.114	(-0.09)	0.05	0.096	-
TOTALS Y + X	0.150	0.068	0.118	0.149	0.144	0.29	0.07	0.134	-

$\bar{X}_D = 0.095$ $S_D = 0.031$ $S_r = 0.022$

$\bar{X}_T = 0.140$ $S_d = 0.048$ $CV_d = \frac{0.048}{0.086} = 0.56$

$F = \frac{S_d^2}{S_r^2} = \frac{0.0023}{0.00048} = 4.79$ Therefore significant systematic error

$S_b^2 = 0.0009$ $S_b = 0.030$

$CV_A = \frac{0.048}{0.087} = 0.55$

THIRD ROUND COLLABORATIVE TEST (D samples)

Low Range Part A: Nominal Value $X = 0.289$ $Y = 0.374$

LABORATORY	A	B	C	D	E	F	G	H	I
SAMPLE X	0.298	0.188	0.296	0.298	0.324	0.35	0.24	0.260	-
SAMPLE Y	0.395	0.336	0.476	0.570	0.505	0.58	0.43	0.420	-
DIFFERENCE Y - X	0.097	0.148	0.180	0.772	0.181	0.23	0.19	0.160	-
TOTALS Y + X	0.693	0.524	0.772	0.868	0.829	0.93	0.67	0.680	-

$\bar{X}_D = 0.182$ $S_D = 0.053$ $S_r = 0.037$

$\bar{X}_T = 0.746$ $S_d = 0.092$ $CV_d = \frac{0.092}{0.332} = 0.28$

$F = \frac{0.0084}{0.0014} = 6.0$ Therefore Significant systematic error

$S_b = 0.059$

$CV_A = \frac{0.092}{0.33} = 0.28$

THIRD ROUND COLLABORATIVE TEST (D samples)

Low Range Part B: Nominal $X = 0.459$ $Y = 0.497$

LABORATORY									
SAMPLE X	0.475	0.312	0.466	0.518	0.573	0.52	0.42	0.400	-
SAMPLE Y	0.510	0.368	0.455	0.500	0.603	0.60	0.49	0.490	-
DIFFERENCE									
Y - X	0.035	0.056	(-0.011)	(-0.018)	0.030	0.08	0.07	0.090	-
TOTALS									
Y + X	0.985	0.680	0.921	1.018	1.176	1.12	0.91	0.890	-

$\bar{X}_D = 0.048$ $S_D = 0.029$ $S_r = 0.021$

$\bar{X}_T = 0.963$ $S_d = 0.108$ $CV_d = \frac{0.108}{0.478} = 0.23$

$F = \frac{0.108^2}{0.021^2} = \frac{0.0117}{0.0004} = 29.3$ Therefore significant systematic error

$S_b = 0.075$

$CV_A = \frac{0.108}{0.478} = 0.22$

The F test is used to determine if significant bias or systematic error (S_b) is present.

In the first round, low range and mid-range, the precision and bias are comparable (0.036 versus 0.044 and 0.084 versus 0.095, respectively) but in the high range precision (0.106) exceeds bias (0.075). In the second round, ultra low range, very low range and low range, precision and bias are again approximately equal (0.024 versus 0.027, 0.019 versus 0.038 and 0.021 versus 0.035, respectively). This trend continues in the third round of collaborative tests except in low range Part A+B. where bias exceeds precision, (0.037 versus 0.059 and 0.021 versus 0.075). The precision and bias of very low range are essentially the same (0.022 versus 0.030).

The precision (S_r) and bias are shown to be equal at lower values, but at higher values, random error is greater than systematic error or bias. This is as expected.

The results of the collaborative test provided one of the two components necessary in computing the uncertainty of the reported results. By dividing the S_d (standard deviation of the data) by the mean of the data for each pair of tests the coefficient of variation (CV_A) for the analytical method can be ascertained. For example: from the first round - high range table, $S_d = 0.150$, $\bar{X} = 2.14$

therefore $CV_A = \frac{0.150}{2.14} = 0.07$ and similarily for the second round - ultra low range, $S_d = 0.046$ and Mean value = 0.057

$$CV_A = \frac{0.046}{0.057} = 0.81$$

It is apparent that the coefficient of variation increases as the concentration of the solution decreases. These values of CV_A were used to draw the curve represented in Fig. 4.1. The coefficient of variation defined in this way is used to calculate the uncertainty of individual measurements in Chapter 4.

3. DUPLICATE SAMPLE ANALYSIS RESULTS

About 1% of all laboratory samples for chromotropic acid analysis were to be split by the various consortium laboratories and sent to Concord Scientific for duplicate analysis. Eighty-eight such samples were received and analyzed (about 90% of the expected number).

The raw analytical data are given in Appendix B (ii). Individual pairs of results (Concord and the originating lab) were subjected to statistical analysis to determine whether there were significant differences between the two sets of data. The following table displays the Student's t-test results for those data.

The presence or absence of a statistically significant difference between Concord's results and the those of the originating laboratory cannot be used to demonstrate the accuracy of either set of results. The t-test results, however, do indicate that there was no systematic difference (overall or individually) between the two sets of independent field and laboratory determinations. In other words, the precision of these independent measurements is within bounds determined by (small) random errors.

Table 3.1

t-Test Results

Collaborative Test Data - Split Samples, Comparison with CSC

LABORATORY	n	$\bar{\Delta}$	s	$s_{\bar{\Delta}}$	t	$t'_{.01,n-1}$	SIGNIFICANCE
Enviroclean	23	-0.0014	0.0284	0.0059	0.24	2.82	N.S.
Proctor & Redfern	4	0.0108	0.0025	0.0013	(8.64)	5.84	S.**
Technitrol	30	-0.0042	0.0096	0.0018	2.40	2.76	N.S.
Atlantic Analytical	8	-0.0021	0.0216	0.0077	0.28	3.50	N.S.
Levelton	21	-0.0020	0.0198	0.0043	0.47	2.85	N.S.
Geortec	2	0.0430	0.0551	0.0390	(1.10)	63.66	N.S.**
Overall	88	0.0021	0.02140	0.0023	0.91	2.64	N.S.

Notes:

* N.S. = not significant; S = significant

** Questionable because of small sample size

n = Number of samples

$\bar{\Delta}$ = Mean value of paired differences (Concord result - Lab X result)

S = Standard deviation

$S_{\bar{\Delta}}$ = Standard error of the mean difference

t = Student's t-statistic for the data = $|\bar{\Delta}|/S_{\bar{\Delta}}$

t' = Student's t-statistic at the 99 % confidence level and n-1 degrees of freedom

SIGNIFICANCE: The observed mean difference is significantly different from zero if $t \geq t'$

4. OVERALL ERROR ANALYSIS

An error analysis was performed on the data to ascertain the major and minor sources of error in the reported results.

The NIOSH standard for air monitoring accuracy stipulates that the total error (sampling plus analysis) should be less than 25 % in at least 95 % of the samples analyzed.

The standard adopted for this study was that the absolute total error should be less than 15 % at least 90 % of the time.

It has become evident from our field visits and the collaborative study that the 15 % error limit has been exceeded and so has the 25 % limit set by NIOSH for this method.

The object of the following is to show what absolute total error can be assigned to individual results obtained during the national survey.

For a standard which allows an absolute total error of 25 % or less in at least 95 % of the samples analyzed, the true coefficient of variation of the total eror (CV_T) should be no greater than 0.128. However, the reported CV is subject to certain random errors. Therefore, the experimental value of the coefficient of variation of the total error ($\overline{CV}_T$) must be lower than the CV_T. Allowing for 5 % of Type I errors this value becomes 0.105. This adjustment is made so that the calculated error bars will reflect the true overall uncertainty at the specified confidence level.

For a maximum absolute total error of 15% in at least 90% of the samples taken and analyzed the time coefficient of variation of the total error (CV_T) should be no greater than 0.091.

The actual CV_T is composed of three components as follows:

$$CV_T = \sqrt{(CV_A)^2 + (CV_S)^2 + (CV_P)^2}$$

Where CV_A is the coefficient associated with the variation of analysis.

CV_S is the coefficient associated with the variation associated with sampling, and

CV_P is the coefficient associated with pump error.

Examples of items associated with each of the above are:

CV_S - transferring liquid from impingers to transfer bottles
- rinsing impingers into transfer bottles

CV_A - collaborative study

CV_P - initial calibration
- replicate analysis
- condensation in rotameters
- frequency of rotameter adjustment
- frequency of recalibration
- measured low rates

For the purpose of this study CV_S and CV_P were combined to $CV_{(S+P)}$ giving the formula

$$CV_T = \sqrt{CV_A{}^2 + CV^2_{(S+P)}}$$

as the operative formula.

Normally one CV_A is determined for an analytical method, however, in this instance since most of the collected samples were at the lower end of the scale, where CV_A increases with decreasing concentration, variable values were used depending upon the range in which the analytical result fits.

Results of the collaborative study reported in chapter 2 of this report provided the data necessary to plot the CV_A vs Concentration curve on the next page. (Figure 4.1)

To use the curve, find the reported value on the X-axis, notice where it intersects the curve and read the corresponding value from the Y-axis. For example, a reported value of 0.1 ppm in air yields a CV_A of 0.12.

The value for $CV_{(S+P)}$ was calculated from results reported in chapter 1,part 1.2. The mean value obtained was 0.16. This value was lower than earlier anticipated but is still approximately three times its normal value. There were certain very high negative and positive values which cancelled to produce the mean value of 0.16. To ascertain the uncertainty associated with any reported value, a calculation must be made which includes a CV_A associated with that value and the $CV_{(S+P)}$ value of 0.16.

As an illustration consider the reported value of 0.2 ppm. From the CV_A curve, the CV_A at 0.2 ppm is 0.12.

$$\text{Therefore } CV_T = \sqrt{(0.12)^2 + (0.16)^2}$$

$$= \sqrt{0.0144 + 0.0256}$$

$$CV_T = 0.2$$

Hence the true value for the sample at 90% confidence

$$TV = \text{reported value} \pm 1.65 \times CV_T \times \text{reported value*}$$

$$TV = 0.2 \text{ ppm} \pm 1.65 \times 0.2 \times 0.2$$

$$= 0.2 \text{ ppm} \pm 0.066$$

Table 4.1. which follows Fiqure 4.1. summarizes various values.

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* 1.65 = number of standard deviations necessary to encompass the 90 % level of confidence limits.

Figure 4.1 COLLABORATIVE TESTING

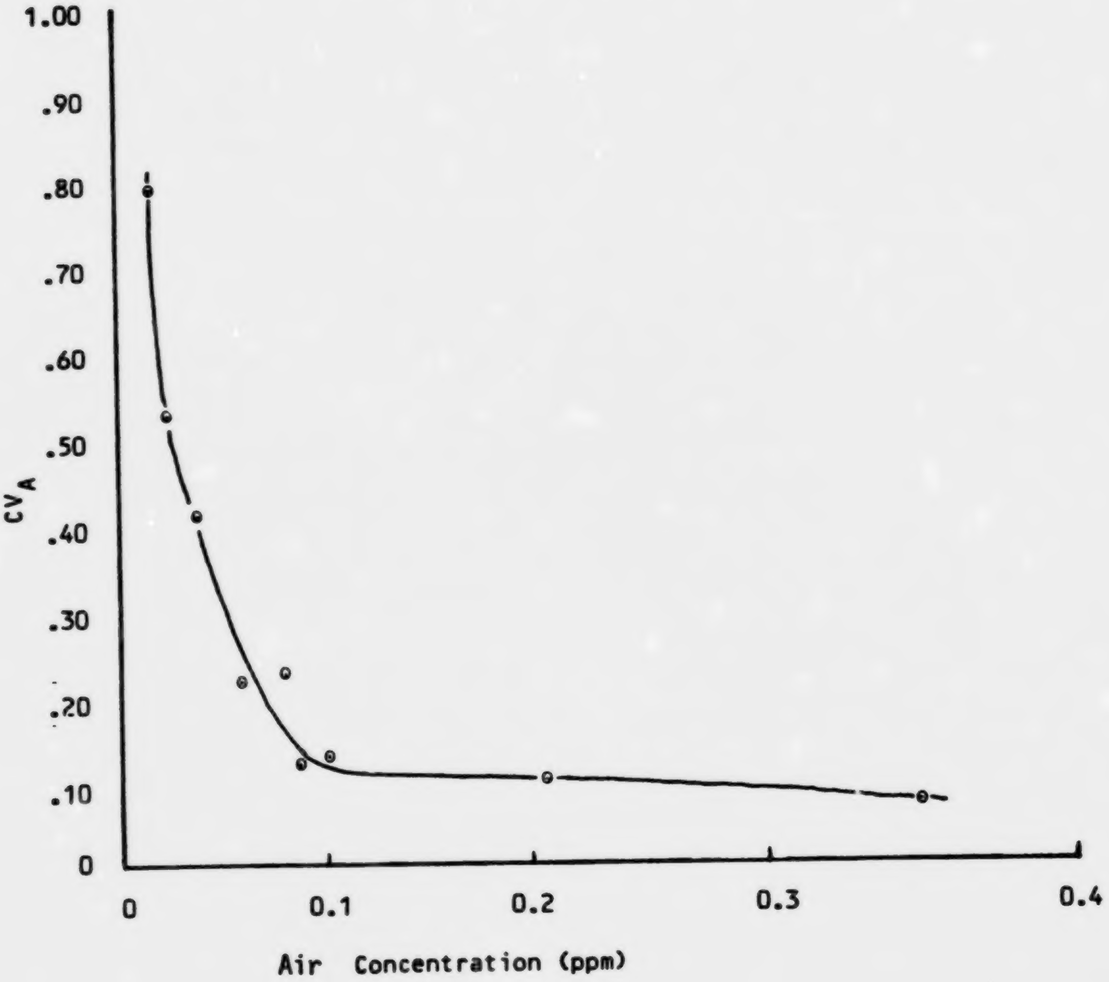

TABLE 4.1

OVERALL UNCERTAINTY OF RESULTS

REPORTED CONCENTRATION	CV_T	UNCERTAINTY*	% UNCERTAINTY**
0.20 ppm	0.20	± 0.066	33
0.15	0.21	± 0.052	34
0.10	0.23	± 0.038	38
0.08	0.26	± 0.034	43
0.06	0.29	± 0.029	48
0.05	0.32	± 0.027	54
0.04	0.38	± 0.025	63
0.03	0.43	± 0.021	70
0.02	0.55	± 0.018	90
0.01	0.77	± 0.013	130

The magnitude of the uncertainty decreases with concentration in the table; however, the percentage of the reported value increases dramatically for concentrations lower than 0.1 ppm. This reflects the increase in CV_A below 0.1 ppm.

---

* % At 90% confidence level

** For 'normal' CV_p of 0.05, each value in the column would be reduced by about 20 %.

5. CERTIFICATION REQUIREMENT RESULTS

A certification document was developed by Concord Scientific as a vehicle for consortium members to vouch that certain training programs had been given to specific individuals who were to perform field and laboratory tasks.

Certifications were received from the following consortium members.

Technitrol
Scanada
Proctor and Redfern
MacLaren Plansearch (Ontario)
Geortec
Atlantic Analytical Services
Levelton
National Testing Laboratories

The certifications name 107 field personnel and 25 lab personnel. The copies of the certifications appear in Appendix D.

6. ASSESSMENT OF FIELD AND LABORATORY DATA SHEETS

One of Concord's requirements was to addess approximately 10% of the data sheet packages recieved to determine whether the quality control criteria that had been specified were met in this statistical sample of the data. The major quality control checks were:

1) Relative difference between formaldehyde concentrations of replicate pairs of NIOSH impinger samples: less than 15%.

2) Formaldehyde concentration in field blank samples: less than 0.125 ug/ml

3) Relative 'average' Drager wall cavity to NIOSH room air formaldehyde concentrations should typically not fall outside of the range 1:5 to 1:60; otherwise, flag result as questionable and investigate.

These quality control criteria were to be tabulated by the consortium field supervisors to indicate that they were carrying out the specified quality control activities regularly. These data were to be summarized in a weekly report to Concord, polled by telephone and using the format provided (see 'Weekly QA/QC Summary' sheet in Appendix E). Failure to meet the quality control criteria does not mean that the data are invalid, merely that causes of possible error should have been sought.

As indicated in the weekly quality assurance reports given at at the Ottawa progress meetings (see Appendix E), these data were not generally provided until the survey was essentially complete (see quality assurance report for November 2, 1981). The only consortium member to provide complete summaries was Levelton.

As of November 6, about 1,200 sets of data sheets had been received at Concord Scientific. Somewhat more than one hundred of these were reviewed. The results of the review are given in the following table.

One of the 117 sets of data sheets checked, 49 or 42% did not meet one or more of the QC criteria indicated by the table headings. About three-quarters of the variations were failure to meet the rule-of-thumb criterion for the ratio of the wall cavity formaldehyde concentration to the corresponding room air concentration. Housing construction and other factors govern this ratio in addition to operator error.

The original intent of this exercise was to check the consistency of QC results reported by the consortium. In the absence of such data, which were not supplied by the consortium, the original intent could not be realized. The sample reviewed, however, does suggest that a significant number of failures to meet the QC criteria should have been flagged by field supervisors during the course of the testing program and remedial feedback measures considered. The relative haste with which the program was conducted prevented, in part, the achievement of this aspect of quality control.

Table 6.1 Field Data Sheet Review

HOUSE I.D. NUMBER	REGION	SAMPLING TEAM	REPLICATE PAIRS NO. DONE	DIFF DONE >15%	BLANKS NO. DONE	>0.5 µg/4ml	WALL CAVITY /ROOM AIR 5<D/N<60
ACTS 7950	Ont.	Sparfel/Ferguson	1	0	1	0	ok
ACTS 10888	Ont.	Lenahan	1	0	1	0	ok
2662	Ont.	Ruest/Fortier	0	0	1	0	>60
3214	Ont.	MG/AC	0	0	1	0	control home
CF2656	Ont.	Lenahan/ MacDonald	1	0	1	0	control home
3156	Ont.	AC	0	0	1	0	ok
381	Ont.	Sansom	1	0	1	0	>60
CF2823	Ont.	Sparfel	1	0	1	0	control home
6013	Ont.	Filson/Beraueh	0	0	0	0	ok
5975	Ont.	Brany	0	0	0	0	ok
7802	Ont.	Beraueh/Effio	0	0	0	0	ok
5895	Ont.	J der Four	0	0	0	0	>60
6040	Ont.	Filson/Linstom	0	0	0	0	<5
6036	Ont.	Filson/Beraueh	0	0	0	0	ok
5983	Ont.	Beraueh	0	0	0	0	ok
ACTS 7092	Ont.	Langan/Tost	0	0	1	0	ok
3219	Ont.	Cosburn/Rockel	1	1	2	0	ok
ACTS 418	Ont.	Naraine/Doan	0	0	1	0	ok
8001	Ont.	Chow	0	0	1	0	ok
2711	Ont.	Perry/Donahue	1	1	1	0	ok
ACTS 4829	Ont.	Ferguson/Sparfel	1	0	1	1	ok
4261	Ont.	Sansom/Moore	0	0	1	0	ok
4262	Ont.	Sansom/Moore	0	0	1	0	ok
4536	Ont.	Littleproud/ Golan	0	0	1	0	<5
CF1501	Ont.	Proszonski/ Poynton	0	0	1	0	control home
3191	Ont.	Sparfel	1	0			

HOUSE I.D. NUMBER	REGION	SAMPLING TEAM	REPLICATE PAIRS NO. DONE	REPLICATE PAIRS DIFF DONE >15%	BLANKS NO. DONE	BLANKS >0.5 mg/4ml	WALL CAVITY /ROOM AIR 5<D/N<60
5102	Ont.	Chow/ MacDougall	0	0	1	0	>60
2927	Ont.	Perry/Donohue	1	1	1	0	ok
2944	Ont.	Ashbec/Heine	1	1	1	0	ok
2588	Ont.	Poynton/ Proszonski	0	0	1	0	ok
3010	Ont.	Ashbee/Perry	0	0	1	0	>60
ACTS 3565	Ont.	Cormack	0	0	1	0	<5
7632	Ont.	Perry/Ashbee	0	0	1	0	ok
2760	Ont.	Ashbee/Perry	0	0	1	0	ok
4455	Ont.	Littleproud/ Golan	0	0	1	0	control home
2936	Ont.	Ashbee/Heine	1	1	1	0	>60
3210	Ont.	Cosburn/Rockel	0	0	1	0	>60
4283	Ont.	Cosburn/Rockel	1	1	1	0	ok
4428	Ont.	Littleproud/ Golan	1	0	1	0	ok
4533	Ont.	Dunne/Sovel	1	0	1	0	>60
4687	Ont.	Chow/MacDougall	0	0	1	0	ok
4939	Ont.	Ashbee/Heine	1	0	1	0	ok
5388	Ont.	Chow/MacDougall	0	0	1	0	ok
7655	Ont.	Poynton/ Proszonski	0	0	1	0	ok
CF4130	Ont.	Manlay/Cormack	0	0	1	0	control home
CF1775	Ont.	Ashbee/Heine	0	0	1	0	control home
ACTS 84	Ont.	Perry/Donahue	1	0	1	0	ok
ACTS 7890	Ont.	Dunne/Savel	1	1	1	0	ok
3618	Ont.	Rockley/Sansom	0	0	1	0	ok
3724	Ont.	AC/Pk	0	0	1	0	>60
99-6494	Ont.	Lenahan/Sparel	2	0	2	0	ok
99-3228	Ont.	Ruest/Kingswood/ Fortier	0	0			ok

			REPLICATE PAIRS		BLANKS		WALL CAVITY
HOUSE I.D. NUMBER	REGION	SAMPLING TEAM	NO. DONE	DIFF DONE >15%	NO. DONE	>0.5 mg/4ml	/ROOM AIR 5<D/N<60
3563	Ont.	AC/SS	0	0	1	0	ok
3569	Ont.	Lenahan/Sparfel	0	0	1	0	ok
4067	Ont.	GR/SS	0	0	1	0	control home
4191	Ont.	Sparfel/Sansom	0	0	1	0	ok
5013	Ont.	Rockley/Kingswood	2	0	2	0	ok
99-3026	Ont.	AC/PK	0	0	1	0	ok
99-1715	Ont.	Littleproud/ Golan	0	0	1	0	ok
99-5082	Ont.	Dunne/Savel	1	0	2	0	ok
3817	Ont.	Ashbee/Chow/ Manley	0	0	1	0	ok
6157	Ont.	Littleproud/ Ashbee/Dunne/ Naraine	1	0	1	0	ok
99-3884	Ont.	Naraine/Brodhead	0	0	1	0	ok
3815	Ont.	Burch/Perry/ Cormack/Thatcher	0	0	1	0	ok
5451	Ont.	Littleproud/ Golan	1	1	0	0	ok
3877	Ont.	Litleproud/ Ciccone	0	0	1	0	ok
3306	Ont.	Burch/Poynton	0	0	1	0	ok
3309	Ont.	Burch/Poynton	0	0	1	0	ok
7233	B.C.	N. Jug	0	0	1	0	>60
99-1660	B.C.	MacLean	0	0	1	0	>60
99-7064	B.C.	Larnetric	0	0	1	0	>60
7043	B.C.	Woodfield	0	0	1	0	>60
7324	B.C.	MacLean	0	0	1	0	ok
99-2201	B.C.	Quigley	0	0	1	0	ok
99-7175	B.C.	Redekop	0	0	1	0	>60
CF6634	B.C.	Cernetric	0	0	1	0	control home
7116	B.C.	Cernetric	0	0	1	0	ok

HOUSE I.D. NUMBER	REGION	SAMPLING TEAM	REPLICATE PAIRS		BLANKS		WALL CAVITY /ROOM AIR 5<D/N<60
			NO. DONE	DIFF DONE >15%	NO. DONE	>0.5 mg/4ml	
99-440	B.C.	Cernetric	0	0	1	0	>60
99-25	B.C.	Blake	0	0	1	0	>60
99-4193	B.C.	Blake	0	0	1	1	>60
99-1275	B.C.	Blake	0	0	1	0	>60
7224	B.C.	Maclean	0	0	1	0	>60
6944	Alta.	Redekop	0	0	1	0	ok
7005	Alta.	Redekop	1	1	1	0	>60
6993	Alta.	Lamfranco	0	0	1	0	>60
6909	Alta.	Mackay	0	0	1	0	control home
6815	Sask.	Mackay	0	0	1	0	ok
6725	Sask.	Quigly	0	0	1	0	ok
ACTS 2894	Sask.	Mackay	1	1	2	0	>60
6853	Sask.	Quigly	0	0	1	0	ok
6748	Sask.	Mackay	0	0	1	0	ok
6073	Man.	Cernetric	1	1	1	0	>60
6452	Man.	Bilbey	0	0	1	0	ok
6128	Man.	McVicor	1	0	1	0	>60
6157	Man.	Cernetric	1	1	2	0	ok
6060	Man.	McVicor	1	1	1	0	ok
6639	Man.	McVicar	1	1	1	0	ok
CF90027	Man.	McVicor	0	0	1	0	control home
ACTS 29	Man.	Kevich	1	1	1	1	>60
6178	Man.	McVicor	0	0	1	0	ok
ACTS 7954	Man.	Boucher	1	1	1	0	ok
6419	Man.	McVicor	1	0	1	0	ok
6252	Man.	Kevich	0	0	1	0	ok
6241	Man.	Kevich	0	0	1	1	>60
6313	Man.	Bilbey	0	0	1	0	>60
6492	Man.	Kevich	0	0			

HOUSE I.D. NUMBER	REGION	SAMPLING TEAM	REPLICATE PAIRS NO. DONE	REPLICATE PAIRS DIFF DONE >15%	BLANKS NO. DONE	BLANKS >0.5 mg/4ml	WALL CAVITY /ROOM AIR 5<D/N<60
ACTS 2033	Nfld.	Thomson		0	1	0	ok
164	Nfld.	McLagan/Snow	0	0	1	0	ok
ACTS 8890	Nfld.	Thomson	1	0	1	0	>60
135	Nfld.	Snow/McLagan	1	0	1	0	>60
19	Nfld.	Snow/McLagan	0	0	1	0	>60
127	Nfld.	Snow/McLagan	0	0	1	0	ok
ACTS 741	N.S.	Waite/Barkhouse	1	1	1	1	ok
ACTS 3032	N.S.	Waite/Henderson	1	0	1	1	ok
ACTS 1261	N.S.	Henderson/Ross	1	1	1	1	ok
7190	B.C.	Redkop	0	0	1	0	>60
7325	B.C.	Jung	0	0	1	0	>60

7. CONCLUSIONS

The following conclusions are drawn from the data presented in the foregoing chapters:

1) The table of chapter 4 indicates that the overall variation of the combined sampling/analytical method was greater than anticipated, as described in QA/QC specifications. If we were to define a limit of reliability to characterize the overall method, the following could be chosen:

± 50% overall variation (uncertainty),0.06 ppm

± 100% overall variation (uncertainty),0.02 ppm

A reasonable definition of a limit of reliability, then, would be 0.06 ppm. Lower concentrations would have uncertainty for an individual measurement greater than 50 %.

2) The overall performance of the analytical laboratories was very good, as indicated by the statistics given in chapters 1, 2 and 3.

3) The overall performance of the sampling method was worse than anticipated. The coefficient of variation for this component, for example, was about three times the typical NIOSH expectation of about 6 %.

4) One objective of the study was to produce 90 % valid data. It is not possible to assess whether this criterion was met at this stage (only partial data set reviewed). Judging from the overall laboratory performance and the percent of field duplicates within the criterion (60%), the objective appears to have been approached.

Qualitative assessments can be derived from Concord's field experience. It appeared that 16 of the 20 homes in which parallel sampling was carried out would have produced results of reasonable quality. Generally, no serious problems were observed in the following regions: West (Levelton, et al); Ontario (Scanada, MacLaren); Newfoundland (Geortec).

Some problems were observed in Quebec/Ontario (Technitrol).

Serious problems were observed in Nova Scotia and New Brunswick (Atlantic Analytical, MacLaren).

Parallel sampling was not carried out with Proctor and Redfern or Warnock Hersey field teams.

5) The review of about one-half of the data sheet sets indicated that about 42 % of these did not meet one or more of the quality control criteria, predominantly the wall cavity/room air ratio of formaldehyde concentrations. The basis and meaningfulness of this criterion should be reviewed in light of the extensive data generated by this survey.

6) The entire data base needs to be reviewed critically, especially with the obejctive of evaluating the feasibility of recovering data of questionable quality, as a result of recalibration of NIOSH sampling train flow rate, particularly in the Atlantic Region.

Some recommendations arising from these conclusions are:

(1) More explicit equipment specifications should be given for future surveys of this type, including explicit pump calibration specifications (primary standards, etc.).

(2) A more sensitive combined sampling and analysis method should be considered, so that, for example, a shorter sampling period could be used.

(3) A longer project lead time would have improved the quality of the results, primarily allowing more time for training and laboratory quality control development.

APPENDIX A

Completed QA Audit Forms

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

HOUSE NUMBER Y2

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
	OUTSIDE none					1.4	11.7	100	100		—
	REPLICATE			TOTAL MINUTES		AVERAGE °C					
13	INSIDE Furnace Room 12" above Floor	3833	17/10/81	0924	1123	24.4	24.4	61	64		~~0.012~~ 0.062
A-1	REPLICATE			119 TOTAL MINUTES		24.4 AVERAGE °C					
14	Bedroom 12" from floor	2786	17/10/81	0925	1125	22.2	22.2	67	78		0.060 ~~0.010~~
15	REPLICATE } using their 1% NaHSO3	347	"	120 TOTAL MINUTES		22.2 AVERAGE °C					0.064 (rep)
	BLANK 1% NaHSO3										
	REPLICATE BLANK their 1% NaHSO3 – no different from ours										

FIELD TEAM D. Snow + R. McLagen
CCS – M. Bacan and J. Stevens

DATE 17/10/81

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Consommation et Corporations Canada

Oct 1981

HOUSE NUMBER
8C

Sampling team
D. Iuia Snow
Ruth McEwen

OBSERVATIONS AND PROBLEMS DURING TESTING

TIONAL OBSERVATIONS MADE DURING TESTING

- Samples (Impinger) Taken 10-12" above floor
- Impinger blank left open to air

Note: Well Trained. Apparently Competent Team.

~~[illegible]~~
LaMottes appeared more stable than Air Cadets previously checked.

OBLEMS ENCOUNTERED DURING TESTING

LaMotte Pumps original set At 1.05L
→ 1.1→1.3 varying

Air Cadet 1.0L

After 1hr. LaMotte → 1.1 – 1.4 L (more variable)
1.25L (more stable)

AC ~~[illegible]~~ 1.0L

No adjustment at end of sampling period
LaMottes 0.95 -1.05
AC 0.88

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Concord Scientific Corporation

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

'SE NUMBER
HOUS[illegible]. 3046

9·12

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
11	OUTSIDE Backyard Porch	2786	8/10/81	1551	1747	dry 12.8 10	11.7 wet 10	76	81		not corrected 0.004
	REPLICATE			116 TOTAL MINUTES		12.3 AVERAGE °C					~~0.051~~
9	INSIDE Kitchen 2' from floor level	3416	8/10/81	1545	1739	dry 22.8 19.4	23.3 wet	74	74		0.051
A-3	REPLICATE			113 TOTAL MINUTES		23.1 AVERAGE °C					
10	Living Room 2' from floor level	3471	8/10/81	1548	1745	dry 22.8 20	23 wet	70	72		0.063
	REPLICATE			117 TOTAL MINUTES		23.1 AVERAGE °C					
12	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK										

FIELD TEAM	DATE
CSC M. Baran + M. Eaman / Tim Thomas + Kevin Rothwell + Tim Cahill	8/10/81

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A-4

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

DATE: [illegible]

HOUSE NUMBER 99-3056

SAMPLING TEAM:
Jim Thomas
Kevin Rothwell
Jim Cahill

OBSERVATIONS AND PROBLEMS DURING TESTING

ITIONAL OBSERVATIONS MADE DURING TESTING

Two different rotameter types. Checked frequently, although variation was observed between checks (R25-50 at 28-56, 21-41 and R9 at 8.5)

Solutions made up by lab. Kept with samples on ice.

Sample locations usually opposite ends of house, first floor only.

Wood moisture measurements done using nails as probes.

Sample transfer generally O.K.

Blanks taken directly from $NaHSO_3$ stock solution to sample bottle.

Previous sampling done in house by Warnock Hersey, NIOSH method only for both wall cavity and room air. Results as follows: —

wall cavity ~ 0.06 ppm (2-3 samples)
room air ~ 0.09 ppm (2-3 samples)

OBLEMS ENCOUNTERED DURING TESTING

Sample identification includes verbal description on sample bottle

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATION
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLE
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES - TRANSFER METHODS
(NIOSH) - LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR JOIST?)
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONAIRE
- DISCRETIONARY NOTES

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Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

HOUSE NUMBER [illegible]

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
7	OUTSIDE Backyard approx 20 ft. from house	Dupont 2786	Oct 14, 1981	1846	2033	dry 10.6 wet 7.8	6.3 7.2	69	86		(0.001)
	REPLICATE None			107 TOTAL MINUTES		9.45 AVERAGE °C					
5	INSIDE Small den approx 18 inches above floor	Dupont 3471	Oct 14, 1981	1827	2030	dry 22.2 wet 17.8	22.2 18.3	66	70		0.039
A-5	REPLICATE None			123 TOTAL MINUTES		22.2 AVERAGE °C					
6	First floor (1 story house) hallway approx 18" above floor	Dupont 3833	Oct 14, 1981	1827	2028	dry 22.8 wet 18.1	22.8 18.9	64	70		0.038
	REPLICATE None			111 TOTAL MINUTES		22.8 AVERAGE °C					
8	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK None.										

FIELD TEAM Susanna Henderson & Janet Ross
From CSC Maryann Baran & John Stevens.

DATE Oct 14, 1981

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A-6

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Consommation et Corporations Canada

HOUSE NUMBER
ACTS 2724

Sampling team
Suzanne Henderson
Steve: Ross

OBSERVATIONS AND PROBLEMS DURING TESTING

IONAL OBSERVATIONS MADE DURING TESTING

- Impingers are 18" from floor
- WAIT 30 minutes after drilling to sample
- don't rinse bubbler tube or container after sampling, simply transfer sample

Note: team appears careful + consistent but has insufficient training + poor equipment.

OBLEMS ENCOUNTERED DURING TESTING

- Flow rates of pumps Initially
  "545 → 0.75L } replicates
  543 → 1.45L }
  542 → 1.85-2.1L
  546 → 0.85L

After careful adjustment
"545 → 1.1-1.2
543 → 1.05 - 1.2
542 → 1.35 - 1.5
546 → 0.65

At end of sampling period
"545 → 0.8
"543 → 0.85

Were not aware setting of rates was critical

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

HOUSE NUMBER TS4586

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME		TEMPERATURE °C		RELATIVE HUMIDITY %		BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
				ON	OFF	ON	OFF	ON	OFF		
3	OUTSIDE Backyard approx. 25 ft from house	Dupont 2786	Oct 14 1981	0951	1205	dry 11 wet 7	12 9.5	52	70		(0.003)
	REPLICATE None			134 TOTAL MINUTES		11.5 AVERAGE °C					
1	INSIDE Dining room approx 18 inches above floor	Dupont 3833	Oct 14 1981	0939	1200	dry 24 wet 18	24 18	56	59		0.035
A-7	REPLICATE None			141 TOTAL MINUTES		24 AVERAGE °C					
2	Second floor hallway appok 18" above floor	Dupont 3471	Oct 14 1981	0943	1225	dry 24 wet 19		64			0.047
	REPLICATE None.			162 TOTAL MINUTES		AVERAGE °C					
4	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK None										

FIELD TEAM Shelley Waite & Darlene Barkhouse
From CSC M Baran & J.G. Stevens.

DATE Oct 14, 1981

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Corporate Affairs Canada

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et Corporations Canada

HOUSE NUMBER
ETS 4588

SAMPLING TEAM
Shelley Waite
Darlene Carrhous

OBSERVATIONS AND PROBLEMS DURING TESTING

ITIONAL OBSERVATIONS MADE DURING TESTING

Team Said: Alright to do impinger samples in Rooms where Wall dragers were not done.

- Impinger Blank is left open to air during sample period.

- Forms given to home owner for completion

Height of drager holes not consistant height above floor

- do not do Joist Samples

If hit fire break during drilling perform drager test anyway

- They wait 30 min. After drilling holes before doing drager tests

They don't rinse bubbler tube or container after sampling. Simply transfer sample

- Impingers are 18" from floor

- No temperature correction used for % moisture content

Note: Group Appears Consistant & careful but have insufficient training and poor equipment.

ROBLEMS ENCOUNTERED DURING TESTING

Flow rates of Air pumps were 0.9L, 1.1L and 1.25L

- Pump with initial rate of 1.25 started to fluctuate between 1.0 - 1.4L/min

- Tubing to one impinger became free

did not consider setting flow with rotometer critical

- all pumps were fluctuating at end of sampling period

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Oct 14/81

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

HOUSE NUMBER
CTS 4588

SAMPLING TEAM
Shelley Wait
Darlene Carl

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING

Team Said: Alright to do impinger samples in rooms where wall draegers were not done.

- Impinger blank is left open to air during sample period.

- Forms given to home owner for completion
- Height of draeger holes not consistant height above floor
- do not do joist samples
- If hit fire break during drilling perform draeger test anyway
- They wait 30 min. after drilling holes before doing draeger tests
- They don't rinse bubbler tube or container after sampling. simply transfer sample
- Impingers are 18" from floor
- No temperature correction used for % moisture content

Note: Group appears consistant & careful but have insufficient training and poor equipment.

ROBLEMS ENCOUNTERED DURING TESTING

- Flow rates of air pumps were 0.9L, 1.1L and 1.25L
- Pump with initial rate of 1.25 started to fluctuate between 1.0 - 1.4L/min
- Tubing to one impinger became free
- did not consider setting flow with rotameter critical
- all pumps were fluctuating at end of sampling period

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HOUSE NUMBER 99-328

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ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME		TEMPERATURE °C		RELATIVE HUMIDITY %		BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
				ON	OFF	ON	OFF	ON	OFF		
3	OUTSIDE back porch 12" above porch	3416	8/10/81	0747	1148	dry 11.7 wet 8.9	12.2 8.9	70	~~66~~ 70		0
	REPLICATE			131 TOTAL MINUTES		12.0 AVERAGE °C					
5	INSIDE Kitchen 18" above floor	~~3756~~ 3471	8/10/81	0936	1137	dry 21.1 wet 17.2	22.8 17.8	~~69.5~~ 70	66		0.094
A-9	REPLICATE			121 TOTAL MINUTES		22.0 AVERAGE °C					
6	Living room 14" above floor	2786	8/10/81	·743	1142	dry 21.1 wet 17.2	22.2 17.8	69.5	66		0.098
	REPLICATE			119 TOTAL MINUTES		22.0 AVERAGE °C					
8	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK										

FIELD TEAM M. et Mme Gaston d'Arc
CSC - Maryann Bacon + Marilyn [illegible]

DATE 8/10/81

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DATE: 8 Oct 81

HOUSE NUMBER
99 - 3289

SAMPLING TEAM:
M. St Mon[illegible]
Gaston d'Arc

OBSERVATIONS AND PROBLEMS DURING TESTING

DITIONAL OBSERVATIONS MADE DURING TESTING

Impingers lab calibrated and scored.
$NaHSO_3$ made up daily in volumetric flask.
Outdoor sample taken near power at back.
Indoor samples taken kitchen, living room (opposite ends of house).
No replicates - insufficient equipment.
Blank taken directly from $NaHSO_3$ solution to sample bottle.
Samples identified by location, type.
Sample transfer generally OK.

OBLEMS ENCOUNTERED DURING TESTING

Impinger intakes @ 18" (Were told 12-18").
Rotameters Matheson (150 units, 2 balls) showed variable flow - set points 25-50, varied 22-48 to 35-75. Checking not observed.
Draeger tube not fully broken in first test. Others (?). This team has done 11 houses to date, and found very little wall cavity HCHO.
no ice in cooler.

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATION
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLE
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES - TRANSFER METHODS
(NIOSH) - LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR JOIST?)
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONARE
- DISCRETIONARY NOTES

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HOUSE NUMBER
* 3565

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
3	OUTSIDE on porch in backyard 7' from walls of house	3458	7/10/81	1636	1637	3.9 dry ~~22.2~~ 3.9 wet ~~18.3~~	7.2 ~~23.9~~ 18.3 ~~22.8~~	80	92		0
	REPLICATE			TOTAL MINUTES 122		AVERAGE °C ~~23.1~~ 8.1					
1	INSIDE Living room floor level	3833	7/10/81	1622	1822	dry 22.2 wet 18.3	23.9 22.8	70	75		0.077
	REPLICATE			TOTAL MINUTES 120		AVERAGE °C 23.1					
2	Bedroom floor level	3471	7/10/81	1628	1827	dry 22.2 wet 18.3	23.9 22.8	70	75		0.086
	REPLICATE			TOTAL MINUTES 119		AVERAGE °C 23.1					
4	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK										

A-11

FIELD TEAM MJE /

DATE 7/10/81

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Consommation et Corporations Canada

DATE: [illegible]

HOUSE NUMBER
ACTS-7330

SAMPLING TEAM:
Mark Vermeer &
Maurice Cenigrossi

OBSERVATIONS AND PROBLEMS DURING TESTING

DDITIONAL OBSERVATIONS MADE DURING TESTING

Air Cadet Cole Palmer Pumps, Model # 7530-40.
Lab Crest Century Rotameter #442-225 (20 units).

NaHSO3 made up daily - 1g crystal and 100 mL deI water (measured with impinger calibrated + scored by lab).
absorbing solutions, samples kept on ice.
Sampling locations living room, bedroom (although UFFI in downstairs walls only). Outside samples within pump cord length of house.
Drilling completed, holes taped, before any Draeger samples done.
Questionaire (FR.) administered as written, some leading.
Blank taken directly from $NaHSO_3$ bottle to sample bottle.
Sample transfer generally O.K.

OBLEMS ENCOUNTERED DURING TESTING

Sampling equipment at floor level.
Rotameters show variable flow (8.8 - 9.2). Checked only once.
Sample #1 small spill during sample transfer. Discretionary notes few.

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATION
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLE
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES - TRANSFER METHODS
(NIOSH) - LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR JOIST?)
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONAIRE
- DISCRETIONARY NOTES

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HOUSE NUMBER 79-328

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME		TEMPERATURE °C		RELATIVE HUMIDITY %		BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (P.P.M.)
				ON	OFF	ON	OFF	ON	OFF		
13	OUTSIDE Backyard - on porch 3' from house	3833	1/10/81	0855	1051	9.4	10.0	69	69	764.0	0.004
	REPLICATE			116 TOTAL MINUTES		9.7 AVERAGE °C					
16	INSIDE Living room	3458	1/10/81	0850	1048	20.6	21.1	62	62.5	764.0	0.018
A-13	REPLICATE			118 TOTAL MINUTES		20.8 AVERAGE °C					
15	Bedroom	3471	9/10/81	0859	1053	21.1	22.2	71	59	764.0	0.039
	REPLICATE			114 TOTAL MINUTES		21.7 AVERAGE °C					
14	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK										

FIELD TEAM: CSC M. Eaman + J. Lux / Steve + Ron

DATE: 7/10/81

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DATE: [illegible]

HOUSE NUMBER
ACTS-7330

SAMPLING TEAM:
Mark [illegible]
Maurice [illegible]

OBSERVATIONS AND PROBLEMS DURING TESTING

DITIONAL OBSERVATIONS MADE DURING TESTING

Air Cadet Cole Palmer Pumps, Model # 7530-40.
Lab Crest Century Rotameter # 442-225 (20 units).

$NaHSO_3$ made up daily - 1g crystal and 100 mL deI water (measured with impinger calibrated + scored by lab).
absorbing solutions, samples kept on ice.
Sampling locations living room, bedroom (although UFFI in downstairs walls only). Outside sample within pump cord length of house.
Drilling completed, holes taped, before any Draeger samples done.
Questionnaire (FR.) administered as written, some leading.
Blank taken directly from $NaHSO_3$ bottle to sample bottle.
Sample transfer generally O.K.

OBLEMS ENCOUNTERED DURING TESTING

Sampling equipment at floor level.
Rotameters show variable flow (8.8 - 9.2). Checked only once.
Sample #1 small spill during sample transfer. Discretionary notes few.

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATION
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLE
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES - TRANSFER METHODS
(NIOSH) - LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR JOIST?)
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONNAIRE
- DISCRETIONARY NOTES

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HOUSE NUMBER 79-328

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME		TEMPERATURE °C		RELATIVE HUMIDITY %		BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
				ON	OFF	ON	OFF	ON	OFF		
13	OUTSIDE Backyard - on porch 3' from house	3833	1/10/81	0855	1051	9.4	10.0	69	69	764.0	0.004
	REPLICATE			116 TOTAL MINUTES		9.7 AVERAGE °C					
16	INSIDE Living room	3458	1/10/81	0850	10:48	20.6	21.1	62	62.5	764.0	0.018
A-13	REPLICATE			118 TOTAL MINUTES		20.8 AVERAGE °C					
15	Bedroom	3471	9/10/81	0859	1053	21.1	22.2	71	59	764.0	0.039
	REPLICATE			114 TOTAL MINUTES		21.7 AVERAGE °C					
14	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK										

FIELD TEAM CSC M. Eaman + J. Lux / Steve + Ron

DATE 7/10/81

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DATE: [illegible]

HOUSE NUMBER
99-3287

SAMPLING TEAM:
Steve
Ron

OBSERVATIONS AND PROBLEMS DURING TESTING (Dechuityd Montreal)

ONAL OBSERVATIONS MADE DURING TESTING

Sample locations indoors, main criterion seems to be opposite ends of house. Backyard sample near power.

Appropriate at this location.

ample designation A, B only.

Sample solutions obtained from lab, kept on ice.

sample transfer generally O.K.

S ENCOUNTERED DURING TESTING

Blanks done.

nlets of impingers at 12".

tameters variable, Outside rotameter flow seems low. Team was asked to have calibration checked.

CHECKLIST

SAMPLING LOCATION - UFFI INSTALLATION
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLE

SAMPLING VOLUME RELIABILITY

ABSORBING SOLUTIONS - PREPARATION
- STORAGE

SAMPLES - TRANSFER METHOD
(NIOSH) - LABELLING
- STORAGE
- BLANKS, REPLICATES

DRAEGER - LOCATIONS (FLOOR JOIST?)
- USE OF PUMP, TUBES

DATA - ADMINISTRATION OF QUESTIONNAIRE
- DISCRETIONARY RATES

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Oct 15/81

HOUSE NUMBER 539

Team
Fernand Pe
Phil Morr

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
	OUTSIDE										
11	Neighbour started burning leaves	2786	15/10/81	13:00	14:28	dry 19.4 wet 14.4	21.1 15.6	60%	56%		(0.018)
	REPLICATE None			TOTAL MINUTES 88		AVERAGE °C 20.3					
	INSIDE										
9	Small Bedroom on North West Corner	3833	15/10/81	1306	1504	dry 21.1 wet 17.2	22.8 18.9	68	70		0.043
	REPLICATE			TOTAL MINUTES 118		AVERAGE °C 22.0					
10	Kitchen	3471	15/10/81	1316	1512	dry 22.2 wet 18.3	24.4 20.0	70	67		(0.028)
	REPLICATE			TOTAL MINUTES 116		AVERAGE °C 23.3					
12	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK None										

A-15

FIELD TEAM Fernand Pelletier + Phil morrison
CSC - Maryann Baran + John Stevens

DATE Oct 15/81

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Oct 15/81

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HOUSE NUMBER
589

Sampling team
Fernand [illegible]
Philip [illegible]

OBSERVATIONS AND PROBLEMS DURING TESTING

DDITIONAL OBSERVATIONS MADE DURING TESTING

- used pipets to fill impingers but dropped pipe on floor when finished
- one reading of sling psychrometer only
- Blank is put directly into sample bottle, NOT into an impinger
- Constantly leaves door open when going in + out
- Not aware that neighbour burning leaves would invalid outdoor sample
- do not check flows during Sampling period
- WERE NOT AWARE OF WHEN TO TAKE INTERFERING GAS TEST

Note: Training of Team is inadequate & poor equipment
THEY CHANGE JOBS SO THAT THERE IS NO CONSISTANCY IN THEIR TESTS FROM ONE HOUSE TO ANOTHER.

OBLEMS ENCOUNTERED DURING TESTING

- Not breaking inner tube of draeger tube ie No reading possible
- Pumping draeger 16 times before taking reading
- pump impinger set up ~~wrong~~ meant Air went through rotameter before entering impinger
- pump rates ~ 0.5 l/min
- appears rotameters are faulty

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ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME		TEMPERATURE °C		RELATIVE HUMIDITY %		BAROMETRIC PRESSURE	FORMALDEHY CONCENTRATION
				ON	OFF	ON	OFF	ON	OFF		
D	OUTSIDE NW CORNER OF HOUSE @ 10' FROM HOUSE	CSC 4		12^{45}	14^{45}	11°c	11°c	57%	50%	101.6 764.8 mm Hg	0
	REPLICATE			120 TOTAL MINUTES		11 AVERAGE °C					
A	INSIDE LIVING ROOM	DUPONT 3458		12^{33}	14^{33}	21°c	22°c	55%	57%	101.6 —"—	~~0.007~~ ~~0.044~~ 0.042
	REPLICATE			120 TOTAL MINUTES		21.5 AVERAGE °C					
C	BACK SITTING ROOM	DUPONT 3416		12^{42}	14^{42}	22°c	22°c	56%	56%	101.6 —"—	~~0.023~~ ~~0.144~~ 0.140
	REPLICATE			120 TOTAL MINUTES		22 AVERAGE °C					
B	BLANK										
	REPLICATE BLANK										

FIELD TEAM	DATE
CSC M. J. Gaman / Ken Ruest + Bernie Fortier	17 October 81

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DATE: ____

HOUSE NUMBER
99-4943

SAMPLING TEA
Ken Rd.
Bernie Loth

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING

Rotameters Matheson 150 mm, needle valve external Matheson 31B. Very steady.
Sample inlets @ 30".
Sample location selection as per UFFI good
absorbing solutions prepared daily (8 × 30 mL pipette volumes), kept on ice
Good knowledge of procedures details.
Questionaire self administered by homeowner, with clarification given when needed,
Water source - hospital water NOT purchased de-mineralized water.
Dupont badges placed, 2 outside 2 inside

PROBLEMS ENCOUNTERED DURING TESTING

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATIO
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLE
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES - TRANSFER METHODS
(NIOSH) - LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR JOI
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONAIRE
- DISCRETIONARY NOTES

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Consommation et Corporations Canada

HOUSE NUMBER 4035

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION
	OUTSIDE NONE TAKEN. PUMP MALFUNCTION										
	REPLICATE			TOTAL MINUTES		AVERAGE °C					
C	INSIDE MASTER BEDROOM (Chain N4) ~~[illegible]~~ (0.80Lpm)	DuPont 3458		0843	1130	20°C	20.5°C	57%	58%		.026 ~~0.004~~
A-19	REPLICATE			167 TOTAL MINUTES		20 AVERAGE °C					
B	WEST BEDROOM (Chain N3) ~~[illegible]~~ (0.95Lpm)	CSC4		0858	1120	20°C	20.5°C	57%	58%		.058 ~~0.009~~
	REPLICATE			142 TOTAL MINUTES		20 AVERAGE °C					.061 ~~0.010~~ (rep.)
A	BLANK (Chain N2, N1)										
	REPLICATE BLANK										

FIELD TEAM CSC M. J. Eamon / Harold MacLean

DATE 19 October 81

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Consommation et Corporations Canada

DATE: 19 a

HOUSE NUMBER
H035

SAMPLER
Harold [illegible]

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING

Sampling locations as per UFFI installation good
Impinger inlets @ 30-48"
Indoor samples using MSA pumps w/ rotameters. Mass flow meter readings
1.0 Lpm, 0.85 Lpm. Outdoor sample MSA pump rotameter + DC pump.
NOTE: Their calibration 1.05 and 0.94 Lpm respectively. Outdoor sampler
>10' from house in yard.
Rotameters, flow rates steady.
Mix own absorbing solution with pre-measured quantities.
No replicates - lack of equipment.
Samples taken directly to laboratory, therefore not transferred. Only
impinger stems removed (polypropylene), not rinsed, and
sealed with snap caps.

PROBLEMS ENCOUNTERED DURING TESTING

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATION
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLER
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES (NIOSH) - TRANSFER METHODS
- LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR JOISTS
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONNAIRE
- DISCRETIONARY NOTES

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

HOUSE NUMBER ACIS 793

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED-NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
	OUTSIDE None done										
	REPLICATE			TOTAL MINUTES		AVERAGE °C					
1	INSIDE Children's Bedroom on 2ND Floor 18" above floor	Dupont 2786	Oct 20 1981	0937	1135	dry 21.7 wet 17.8	21.7 18.3	69	73		.045
A-21	REPLICATE None			118		21.7					
				TOTAL MINUTES		AVERAGE °C					
2	Den 18 inches above the Floor		Oct 20 1981	0939	1146	dry 21.1 wet 23.3	17.8 19.4	73	70		.079
3	REPLICATE using their 1% NaHSO3		Oct 20 1981	127		19.5					.07 (rep) .07
				TOTAL MINUTES		AVERAGE °C					
4	BLANK 1% NaHSO3										
5	REPLICATE BLANK using their 1% NaHSO3					Their Blank is no different from ours					

FIELD TEAM Mark Nagle & Neil Moirison
For CSC Maryann Baran.

DATE Oct 20, 1981

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HOUSE NUMBER
ACCF 7934

SAMPLING TEAM
MARK NAG[illegible]
NEIL MORN[illegible]

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING

- were not aware of inner vial that had to be broken in dräger tube — suspect all previous results.
- impingers set about 2½ ft. above floor level.
- don't rinse bubbler tube or container of impinger when transfering sample
- don't put blank into an impinger but straight into sample bottle
- no dräger pump leak test (not even aware of).

Note: Team follows a set routine (ie. same person does same job in every home).

PROBLEMS ENCOUNTERED DURING TESTING

Flow rates of pumps initally	Rotameter Setting.	Kurtz. Mass Flow Meter.
A) in bed room	50, 25	
B) in den	50, 25	
c) outside	45	
- One hour later		
A) in bedroom	62,30	.55 (steady)
B) in den	50,25	.43-.45
c) outside	49	.34-.35
Readjusted A) and waited 5 minutes	50,25	.45 (steady).
At 1½ hour sampling time		
A) bedroom	50,25	.42
B) den	50. 25	.43(steady)
c) outside	43	.27-.28
Readjusted c) and waited 5 min.	45	.32-.34
At end of sampling period		
A) bedroom.	50,25	.43
B) den	51,25	.44-.45
c) outsid	44	.32-.34

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HOUSE NUMBER 3618

~~no spls received~~

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (P.P.M.)
3	OUTSIDE in backyard approx 10 ft. from house.	3458	6/10/81	1142	1335	17.5	222	57	65		not corrected for pressure .004
	REPLICATE			113 TOTAL MINUTES		20.9 AVERAGE °C					.0
1	INSIDE Living room 1½ ft from floor	3471	6/10/81	1134	1336	22.8	239	53	62		.069
A-23	REPLICATE			121 TOTAL MINUTES		23.4 AVERAGE °C					
2	East storage Room 2nd floor 2½ feet from floor	3833	6/10/81	1133	1337	21.7	22.2	65	65		.081
	REPLICATE			119 TOTAL MINUTES		22.0 AVERAGE °C					
4.	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK										

FIELD TEAM Scott Sansom & Gary Rockley From CSC Maryann Baran & John Stevens.	DATE Oct 6, 1981.

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HOUSE NUMBER 3618.

OBSERVATIONS AND PROBLEMS DURING TESTING

DITIONAL OBSERVATIONS MADE DURING TESTING

Team of Scott Sansom & Gary Rockley

Quick with dräger pumping - either not completely compressi or allowing time to completely expand.

1% NaHSO3 not measured volumetrically.

went over questionaire with homeowner.

- rotameters were not carefully leveled when set.
- bottled demineralized water used.

home had cellulose, fibreglass and UFFI
- caps on outside of house loose.
- window on 2ND floor open 1/2 inch - could not be forced to close.

OBLEMS ENCOUNTERED DURING TESTING

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Consommation et Corporations Canada

HOUSE NUMBER 7697

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME		TEMPERATURE °C		RELATIVE HUMIDITY %		BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (P.P.M.
				ON	OFF	ON	OFF	ON	OFF		
7697 F-A	OUTSIDE on Picnic table	CSC D 3T71 1.1L :45	Oct26 1981	#6 1437	1637	51°W 51°D OF	51 53	89	89	30.08 in Hg 764.032 mm	(0)
	REPLICATE			120 TOTAL MINUTES		10.6 °C AVERAGE °C					
7697 F-C	INSIDE Kitchen	CSC 3 1.34/m	Oct26 1981	1428	1630	62°W 75°D	62 72	59	62	30.08 in Hg 764.032mm	.022
F-B	REPLICATE			122 TOTAL MINUTES		16.7°F AVERAGE °C					
7697 F-E	Bed Room 2nd Floor	CSC 8 1.254/m 1.35 1.33	Oct26 1981.	1434	1633	61W 71D	61 71	62	62	30.03 in Hg 764.032mm	.028
	REPLICATE			119 TOTAL MINUTES		16.1°C AVERAGE °C					
7697 F-D	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK										

FIELD TEAM	DATE
J. STEVENS → [Tina Perry + Paul Donahue	Oct. 26/81

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Oct 26 1/81

HOUSE NUMBER
7697

SAMPLING Team
TINA Perry
PAUL DONTA

OBSERVATIONS AND PROBLEMS DURING TESTING

MacLaren Plansearch

DDITIONAL OBSERVATIONS MADE DURING TESTING

Sample #	Dupont's			
6A19	1.1 - 1.15	1.1 - 1.15		1.1 - 1.15
7670	1.1 - 1.15	1.1 - 1.15		1.0 - 1.05
3A02	0.7 - 0.95	0.7 - 0.95		0.55 - 1.05
3441	0.9 (outside	0.6	(0.7 - .85)	0.85

- Pools of liquid from impingers collect in Tubing to pump. Tubing is changed at random

- A brick veneer house. Taking Draegers in STUD SPACE. FOAM is between brick & sheathing. Reading from INSIDE 0.5. Reading OUTSIDE 7ppm.

- Blank is made ~~between~~ by pouring liquid from bottle into sample bottle. ie NOT into impinger.

OBLEMS ENCOUNTERED DURING TESTING

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I STEVENS

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HOUSE NUMBER 4006
Toront

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
1 Their ID No. 4006C	OUTSIDE 1 ft. from house approx. 18 in high	Dupont 3471	23-10-81	1400	pump stopped	dry 11.1 wet 7.8	8.9 6.1	64	67		—
	REPLICATE None			— TOTAL MINUTES		10.0 AVERAGE °C					
2 Their ID No. 4006B	INSIDE 2ND Floor Storage room approx 24 in high	Dupont 2786	23-10-81	1355	1549	dry 17.2 wet 12.2	17.8 12.8	56	56		.041
	REPLICATE None			114 TOTAL MINUTES		17.5 AVERAGE °C					
3 Their ID No. 4006 A	First Floor Washroom approx 18 in high.	CSC7 orifice 1.0C 1.3 ℓ/min	23-10-81	1347	1538	dry 17.8 wet 12.8	18.3 13.3	58	57		0.031
	REPLICATE None			111 TOTAL MINUTES		18.1 AVERAGE °C					
4 Their No. 4006D	BLANK 1% $NaHSO_3$										
	REPLICATE BLANK None										

FIELD TEAM Stephen Gallagher & Ramzan Lakhani
For CSC John Stevens & Maryann Baran

DATE Oct 23, 1981.

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Oct 27, 1981

HOUSE NUMBER 4006

Toronto

OBSERVATIONS AND PROBLEMS DURING TESTING

DDITIONAL OBSERVATIONS MADE DURING TESTING

- Impingers calibrated to 20ml by lab.
- both team members do all jobs.
- If UFFI was installed from outside drager tests are done from outside
- Blank put into impinger and then immediately transfered to a sample bottle.
- Using dosimeters.

OBLEMS ENCOUNTERED DURING TESTING

Initial
Outside .85 l/min
Inside 2ND floor .77 l/min
Inside 1ST floor .45 l/min
} Adjusted with Kurtz mass flow meter to 1 l/min (ie. changed rotameter settings).

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HOUSE NUMBER 2584

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (P
~~8~~	OUTSIDE —— NOT DONE PUMP FAILURE	~~DuPont 3116~~									
	REPLICATE			TOTAL MINUTES		AVERAGE °C					
C	INSIDE BEDROOM (EAST) (Train N·2)	CSC 4	0.95 Lpm	1354	1554	23°c/18°c	22°c/17°c				
	REPLICATE			120 TOTAL MINUTES		22.5 AVERAGE °C					.025
A	LIVINGROOM (Train N-4)	DuPont 3458	0.8 Lpm 45 min 1.0 Lpm	1400	1600	22.5°c/18°c	20.5°c/16°c				~~.025~~
	REPLICATE			120 TOTAL MINUTES		21.5 AVERAGE °C					.041
D	BLANK (Train N-3)										
	REPLICATE BLANK										

FIELD TEAM M. J. Eamon

DATE 19 October 1981

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DATE: 19 Oct

HOUSE NUMBER
2584-

SAMPLING
Norman Yu

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Consommation et Corporations Canada

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING

Three indoor samples taken instead of two in, one out, because this unit in coop housing seems to occupants to be the worst.

Cole Palmer pumps, Matheson rotameters. Adjusted frequently. At their set points, flow is 1Lpm.

Impinger inlets @~36".

Absorbing solutions made up in field with pre-measured $NaHSO_3$, water.

Samples taken in polypropylene impingers to laboratory. Impinger stem NOT rinsed on removal, only tapped. It is however not a tapered stem. Only residual small droplets remain on stem. When outside the city the field team will send samples back in capped impingers, rather than transfer samples.

Sample labelling O.K. Blanks done.

Replicate done by T, 2 rotameters from pump. Once per day.

PROBLEMS ENCOUNTERED DURING TESTING

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATIO
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLE
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES - TRANSFER METHODS
(NIOSH) - LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR JOIST?)
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONNAIRE
- DISCRETIONARY NOTES

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HOUSE NUMBER 6056

Scientific Corporation

ROOM AIR FORMALDYKYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION
	OUTSIDE — Pump dead —										
	REPLICATE			TOTAL MINUTES		AVERAGE °C					
A	INSIDE DINING ROOM (Thein N-1 and N-5)			1405	1605	19°C	19°C	6%	6%		.043
	REPLICATE			120 TOTAL MINUTES		19 AVERAGE °C					
C	BEDROOM (Thein N-4)			1408	1612	22°C	22°C	6.5%	7%		.045
	REPLICATE			124 TOTAL MINUTES		22 AVERAGE °C					
B	BLANK (Thein N3)										
	REPLICATE BLANK										

FIELD TEAM M. J. Eamon

DATE 24 October 81

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DATE: 24 O

HOUSE NUMBER
6056

SAMPLI

Grant Mc V

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Consommation et Corporations Canada

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING

GAST pumps, Matheson rotameters. Set as per calibrated set point (calibrat at beginning in Vancouver) and adjusted regularly.

Condensation problems in rotameters. This tester dries his rotameters every night using the exhaust from pumps.

Observed flow rates DININGROOM replicate T split 1.0 and 0.95 Lpm. (adjusted to 1.0 Lpm @ 1420)
BEDROOM @ 1.0 Lpm O.K.
OUTSIDE @ 1.4 Lpm all outside samples taken with this same rotameter. Set point adjusted for 1.0 Lpm.

DNPH not supplied to tester. If interfering gases encountered, visit required

Samples sent by National Testing Labs to Vancouver weekly.

Field blanks done, Replicates 4/10 houses.

PROBLEMS ENCOUNTERED DURING TESTING

Sample inlets usually @ 18" (unless stool present).

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATIO
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLER
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES - TRANSFER METHODS
(NIOSH) - LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR JOIS
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONNAI
- DISCRETIONARY NOTES

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HOUSE NUMBER 6233

Conestoga Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME		TEMPERATURE °C		RELATIVE HUMIDITY %		BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION
				ON	OFF	ON	OFF	ON	OFF		
	OUTSIDE — PUMP DEAD —										
	REPLICATE			TOTAL MINUTES		AVERAGE °C					
A	INSIDE BACK PORCH (Thein N 3)	DUPONT # 3458	24 OCT 81 1.0 Lpm	0912	1115	Tdb = 21°C Twb = 18°C	SAME			100.6 756.37 mm Hg	.063
	REPLICATE			123 TOTAL MINUTES		21 AVERAGE °C					
C	FRONT PORCH (Thein N 1, N 2*)	DUPONT # 3033	24 OCT 81 0.68 Lpm 45 min, 1.0 Lpm 75 min	0925	1125	Tdb. = 21°C Twb = 18°C	SAME			100.6 756.39 mm Hg	.100
	REPLICATE * NOTE: Thein N 2 flow rate 0.44 Lpm.			120 TOTAL MINUTES		21 AVERAGE °C					
B	BLANK Thein N1 flow rate 1.0 Lpm.										
	REPLICATE BLANK										

FIELD TEAM M. J. Eaman

DATE 24 October 81

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Consommation et Corporations Canada

DATE: 24Q

HOUSE NUMBER 6233

SAMPLI E

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING

Rob Billey

Field blank done as per samples. Replicate done by T junction
Sample locations good as per UFFI (in porch(s) only). Outside sample
done (~ 0°c), no freezing problems.
Impinger inlets @ 36°-48°. Rotameter adjustments frequent (~¼ hourly
Flow checks: FRONT PORCH rep —┤ ① @ 0.44 Lpm ② @ 0.99 Lpm
BACK PORCH @ 0.95 Lpm — No obvious reason for difference in simpl
OUTSIDE @ 1.1 Lpm — T splitting. Recommended to tester that volum
At their set points. — be checked from ① above.
No DNPH. If interfering gases are found, a tester returns at a later
date to sample for interfering gases. Few have been found.
absorbing solution $NaHSO_3$ made up daily in the field.
Polypropylene impingers used for sampling, and shipping. Impinger
stem not rinsed.

PROBLEMS ENCOUNTERED DURING TESTING

Psychrometer thermometers both broken previous to this test location.
QA/QC bought replacement thermometer (outside type) and instructed
on use as T_{db}, T_{wb}.
Note replicate flow rates above.

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATIO
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLE
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES - TRANSFER METHODS
(HCHO) - LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR JOIST)
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONNAI
- DISCREPANCY IN RATES

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

HOUSE NUMBER 667

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION
	OUTSIDE ——→ None done ——					-6°c					
	REPLICATE			TOTAL MINUTES		AVERAGE °C					
A	INSIDE LIVING ROOM (2hin N3)	DUPONT 3458	0.95 lpm 40 min 1.0 lpm	1520	1720	22°c 15°c Twg					.032
	REPLICATE			120 TOTAL MINUTES		22 AVERAGE °C					
B	BEDROOM, 2ND FLOOR (2hin N4)	CSC 4	0.95lpm	1528	1735	21°c 16°c TWB					.025
	REPLICATE			117 TOTAL MINUTES		21 AVERAGE °C					
C	BLANK										
	REPLICATE BLANK										

FIELD TEAM M. J. Caman

DATE 22 Oct 81

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DATE: 22 O

HOUSE NUMBER 6678

SAMPLER – E

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

OBSERVATIONS AND PROBLEMS DURING TESTING

Robert Mail

ADDITIONAL OBSERVATIONS MADE DURING TESTING

Matheson rotameters #603, calibrated to 1.0 Lpm. Set points 50 on one, 61 on other. Observed flow rates 1.0 Lpm (LR), 1.05 Lpm (BR). Rotam adjusted frequently during sampling period.

Impinger inlets @ ~ 30". Sample placement re: UFFI O.K.

absorbing solutions made up in ~ 200 ml volumes with pre-weighed $NaHSO_3$, distilled water (purchased from drug store after supply from Levitton finish. Currently on last of Levitton water.

Samples returned (polypropylene impingers capped and packed in shipping box) every 2-3 days, dependent upon airport locatio DNPH sample taken immediately today to Yorkton airport. Samples not stored or shipped on ice, but currently −6°C.

Replicates done every 4 homes. Blanks prepared with samples. Identi by number only

PROBLEMS ENCOUNTERED DURING TESTING

Outside sampler not placed because of temperature (−6°C). Extra indoor sample not done. Impinger stem not rinsed.

Tester experiencing eye irritation. Appears that Draeger pump, on compression, disperses fine particulate cloud of tube chemicals.

CHECKLIST
SAMPLING LOCATION – UFFI INSTALLATION
– HOUSE DESIGN
– IMPINGER INLET
– OUTSIDE SAMPLE
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS – PREPARATION
– STORAGE
SAMPLES – TRANSFER METHODS
(HCHO) – LABELLING
– STORAGE
– BLANKS, REPLICATES
DRAEGER – LOCATIONS (FLOOR 1ST)
– USE OF PUMP, TUBES
DATA – ADMINISTRATION OF QUESTIONNAIRE
– DISCREPANCIES NOTED

Concord Scientific Corporation

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

HOUSE NUMBER 6792

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME		TEMPERATURE °C		RELATIVE HUMIDITY %		BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION
				ON	OFF	ON	OFF	ON	OFF		
D	~~OUTSIDE~~ (NO OUTSIDE SAMPLE DONE, -6°) BEDROOM	DUPONT # 3458	23 OCT 81 1.0 Lpm	0915	1115						.07[illegible]
	REPLICATE			120 TOTAL MINUTES		AVERAGE °C					
C	INSIDE BASEMENT	CSC # 4	23 OCT 81 0.95 Lpm	0922	1122						.076
	REPLICATE			120 TOTAL MINUTES		AVERAGE °C					
B	LIVING ROOM	DUPONT # 3833	23 OCT 81 1.0 Lpm	0940	1140						.083 ~~.070~~
	REPLICATE			120 TOTAL MINUTES		AVERAGE °C					
A	BLANK										
	REPLICATE BLANK										

FIELD TEAM M. J. Gaman

DATE 23 October 81

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DATE: 23

HOUSE NUMBER 6792

SAMPLIN

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OBSERVATIONS AND PROBLEMS DURING TESTING

Bill Quigl

ADDITIONAL OBSERVATIONS MADE DURING TESTING

Checking flow rates of tester's pumps, rotameters, showed
0.85 Lpm Livingroom
1.0 Lpm Basement
0.55 Lpm Bedroom (* see notes below). Changed rotameters @ 1

absorbing solution prepared in ~ 200 mL volume with pre-weighed $NaHSO_3$ and pipetted water supplied by Levelton or drugstore de-ionized.

Drill hole locations on first floor only (Bungalow style), none in basement

used polypropylene impingers for sampling, sample transfer. Impinger stems not rinsed.

Tester's pump capacity (Cole Palmer) checked, found to be 3.9 Lpm. Theref critical orifice in line might have been better than rotameter. If rotameter used in line between pump and impinger, drying tube needed.

Impinger outlets at 30°-40°.

PROBLEMS ENCOUNTERED DURING TESTING

Taking outside R.H. (T_{wb}) when temperature is well below freezing...

* Condensation in rotameter observed. No testers have drying tubes in their sampling lines; therefore condensation is a likely occurrence in latter part of field sampling this month. The effect appears to be that the water forms a seal around the rotameter ball. In this case, the rotameter had to be adjusted to full scale to obtain a 1 Lpm flow rate. Rotameters were changed. Attempt will be made to dry rotameter.

Blanks not prepared in field.

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATION
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLE
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES - TRANSFER METHODS
([illegible]) - LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR [illegible]
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONNAIRE
- DISCREPANCY RATES

Concord Scientific Corporation

Consumer and Corporate Affairs Canada
Consommation et Corporations Canada

HOUSE NUMBER
3210
Bolton

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (P.P.M.
3210-3	OUTSIDE On front porch SE 2 ft from house Their ID No. F-A	CSC [illegible] 1.0B	28-10-81	1655	1855	wet 5.6 dry 6.7	5.6 6.1	85	92		0.010
	REPLICATE None			120 TOTAL MINUTES		5.6 AVERAGE °C					
3210-1	INSIDE Living Room 18" high Their ID. No. F-C	CSC3 1.0E	28-10-81	1643	1841	wet 17.2 dry 21.7	18.3 22.2	67	69		0.047
	REPLICATE None			178 TOTAL MINUTES		17.8 AVERAGE °C					
3210-2	Christy's Bedroom 3½' high Their ID No. F-B	CSC8 WC	28-10-81	1648	1845	wet 17.2 dry 21.7	18.3 22.2	64	69		0.061
	REPLICATE None			117 TOTAL MINUTES		17.8 AVERAGE °C					
3210-4	BLANK 1% $NaHSO_3$ Their ID No. F-D										
	REPLICATE BLANK None										

FIELD TEAM Paul Cosbourn & Silvia Rockel
For CSC Maryann Baran

DATE Oct 28, 1981

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Oct 28/81

HOUSE NUMBER
3210

OBSERVATIONS AND PROBLEMS DURING TESTING

ITIONAL OBSERVATIONS MADE DURING TESTING

Paul Cosburn & Silvia Rockel

team works routinely doing the same jobs in each home

does questionaire with homeowner

-doesn't do or know of dräger pump leak test

using dosimeters (have been doing for quite some time)
outside — hung on fence by pool)

calibrate pumps every day or every second day

-carry samples in trunk of car — feels that it is cold enough outside to keep samples.

-1% $NaHSO_3$ made up every day

-distilled water from lab.

does all dräger tests from inside of home, however has a very long drill bit.

LEMS ENCOUNTERED DURING TESTING

-wood stove operating in basement

heating supper on stove in kitchen

rinse impingers

pipets blank directly into sample bottle

MSA Portable Pumps.

Living Room	in Bedroom	outside
1.07	1.07 - 1.15	1.25 - 1.40
1.09 - 1.13	1.10 - 1.15	1.25 - 1.40

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HOUSE NUMBER 99·2728
Toronto

Concord Scientific Corporation

ROOM AIR FORMALDYHYDE
(REVISED NIOSH)

SAMPLE NUMBER	LOCATION	PUMP I.D. NUMBER	DATE OF PUMP CALIBRATION	SAMPLING TIME ON	SAMPLING TIME OFF	TEMPERATURE °C ON	TEMPERATURE °C OFF	RELATIVE HUMIDITY % ON	RELATIVE HUMIDITY % OFF	BAROMETRIC PRESSURE	FORMALDEHYDE CONCENTRATION (p.p.m.)
3	OUTSIDE Approx. 6 ft. from house in sheltered corner Their No. 99·2728-O	Dupont 2796	23-10-81	0941	1142	dry 4.4 wet 4.4	8.9 7.8	100	86	101.8 765.4 mm Hg	·008
	REPLICATE None			121 TOTAL MINUTES		6.7 AVERAGE °C					
2	INSIDE Dining Room approx. 2 ft high Their No. 99·2728-M	Dupont 3471	23-10-81	0945	pump stopped	dry 21.1 wet 16.1	20.6 18.3	61	82	101 8	—
	REPLICATE None			Invalid Sample TOTAL MINUTES		20.9 AVERAGE °C					
1	Den approx 2 ft high Their No 99·2728-N	CSC 7 Orifice 1.0C 1.3 l/min	23-10-81	0942	1245	dry 22.2 wet 17.2	23.9 18.9	61	64	101.8	·053
	REPLICATE None			123 TOTAL MINUTES		23.1 AVERAGE °C					
4	BLANK 1% $NaHSO_3$ Their No. 99-2728-P										
	REPLICATE BLANK None										

FIELD TEAM Terry Markell & Jean-Pierre Racine
For CSC John Stevens & Maryann Baran

DATE Oct 23, 1981.

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Oct 23,1981

HOUSE NUMBER
99-27278

Toronto

OBSERVATIONS AND PROBLEMS DURING TESTING

DDITIONAL OBSERVATIONS MADE DURING TESTING

Sampling team already on location when we arrived and the front door was standing wide open " for visitors

Automatic washer & dryer both running in basement. vent for dryer

- Doing Formaldehyde and water vapour from holes drilled on the outside of the house (don't always do this - depends on home construction) Drills into holes previousl made upon installation. - 2 done inside (no access from outside)

Goes over questionaire with homeowner

No problems using drägertubes or pump. - no leak test however

Team works on a routine - don't change jobs.

Using dosimeters

Blank not put through an impinger but staight into sample bottl

Don't rinse impinger

OBLEMS ENCOUNTERED DURING TESTING

ir Cadet pumps

t start of sampling time		At 1100	At 1140
ining Room	.48	.49	.48
edroom	.4	.41	.4
utside	.33	.27	.44

Adjusted all rotameters to new set points which give 1 l/min on Kurtz mass flow meter for future tests.

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A - 43

DATE: [illegible]

HOUSE NUMBER
99-4457

SAMPLING TEAM:
Mike Cahill
André Hirsch

OBSERVATIONS AND PROBLEMS DURING TESTING

TIONAL OBSERVATIONS MADE DURING TESTING

Outside sampler under porch floor overhang, to have it out of the way of the driveway, neighbourhood kids, and near power.

Samples taken at opposite ends of house, ground floor only. No NIOSH samples were taken upstairs.

Floor joist Draeger sample not done. Appears to have been a misinterpretation of procedures manual.

Sample transfer methods good.
Solution, sample storage on ice.

LEMS ENCOUNTERED DURING TESTING

"Replicate" samples on opposite sides of room. This is the first time that the team did replicate samples this way.

Impinger inlets @ ~14"..
Rotameters occasionally adjusted while being held at 45° angle.

Flow substantially different with rotameter at recommended set points. The Alltong AIC single ball type @ 25 showed single individual bubbles in absorbing solution. The Matheson double ball type @ 25,50 showed vigorous bubbling.

Blanks labelled as blanks.
Discretionary notes not done in front of sample spilling. Team will correct.

CHECKLIST
SAMPLING LOCATION - UFFI INSTALLATION
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLER
SAMPLING VOLUME RELIABILITY
ABSORBING SOLUTIONS - PREPARATION
- STORAGE
SAMPLES (NIOSH) - TRANSFER METHODS
- LABELLING
- STORAGE
- BLANKS, REPLICATES
DRAEGER - LOCATIONS (FLOOR JOIST?)
- USE OF PUMP, TUBES
DATA - ADMINISTRATION OF QUESTIONAIRE
- DISCRETIONARY NOTES

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HOUSE NUMBER 3640.

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING

Audit of Sampling Team, Don Lenahan & Ken Sparel.

- using same calibration factors for all rotameters (!?)
- check dräger pump for leaks.

did questionaire with homeowner.

- using air cadet pumps - noticed constant change on rotameter - constantly readjusting.

ROBLEMS ENCOUNTERED DURING TESTING

Note: No side by side sampling done

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HOUSE NUMBER
3703

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING

Audit of Sampling Team, Pat Knox & Andrew Cameron.

- outside pump on varanda close to house.
- since the insulation was only installed on a single floor no sample was taken in a joist.
- no appearent blank
- do not rinse out bubbling tube when transfering sample to sample bottle
- using commercially produced distilled water (purchased)
- using air cadet pumps.

ROBLEMS ENCOUNTERED DURING TESTING

Note: No side by side sampling done.

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HOUSE NUMBER [illegible]

OBSERVATIONS AND PROBLEMS DURING TESTING

DDITIONAL OBSERVATIONS MADE DURING TESTING

October 23, 1981

Team of:
Kevin & Tim - have previously seen in Montreal.

Air Cadet Pumps

Sample No.	Flow (ℓ/min)
3902-E	0.6
3902-F	0.85
3902-G	0.75

Adjusted flow to 1 ℓ/min using Kurtz mass flowmeter to give new rotameter settings for future use.

ROBLEMS ENCOUNTERED DURING TESTING

John Stevens.

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DATE: 20

HOUSE NUMBE
6432

SAMPLING TE
Grey Wood

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING OBSERVATIONS ONLY, NO REPLICATE SAMPLING

GAST pumps, Matheson rotameters. At their set points flow 0.85 Lpm (LR), 1.05 Lpm outside, 1.10 Lpm (bedroom). Flow checked an adjusted.

Impinger inlets @~36". Sampling locations good.

Absorbing solutions made up in field.

Polypropylene impingers. Samples taken to laboratory in impingers, cappe
Impinger stem not rinsed.

Sample labelling O.K. Blanks done. Replicates done once per day.

Questionaire administered.

No floor joist sample done – bungalow.

PROBLEMS ENCOUNTERED DURING TESTING

Pump flow rates, rotameter calibration will be checked.

CHECKLIST

SAMPLING LOCATION - UFFI INSTALLAT
- HOUSE DESIGN
- IMPINGER INLET
- OUTSIDE SAMPLI

SAMPLING VOLUME RELIABILITY

ABSORBING SOLUTIONS - PREPARATION
- STORAGE

SAMPLES - TRANSFER METHODS
(NIOSH) - LABELLING
- STORAGE
- BLANKS, REPLICATES.

DRAEGER - LOCATIONS (FLOOR JOIST ?
- USE OF PUMP, TUBES

DATA - ADMINISTRATION OF QUESTIONN
- DISCREPANCIES IN RATES

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~~HOUSE NUMBER~~ [illegible]

OBSERVATIONS AND PROBLEMS DURING ~~TESTING~~ Lab GA/GC

ADDITIONAL OBSERVATIONS MADE DURING TESTING

- [illegible] electted
- back [illegible] [illegible] dumped
- [illegible] [illegible] [illegible] amber bottle
- [illegible] paper 7 [illegible]
[illegible] maximum [illegible] light for
[illegible] 280 nm

- [illegible] [illegible]
[illegible]

ROBLEMS ENCOUNTERED DURING TESTING

14/10/81

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~~HOUSE NUMBER~~ Technitrol

OBSERVATIONS AND PROBLEMS DURING ~~TESTING~~ and QA/QC

DITIONAL OBSERVATIONS MADE DURING TESTING

- smoking in the lab
- [illegible] bottles
- [illegible]
[illegible] ETONM

BLEMS ENCOUNTERED DURING TESTING

15/10/81

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HOUSE NUMBER
[illegible]

OBSERVATIONS AND PROBLEMS DURING ~~TESTING~~ [illegible]

DDITIONAL OBSERVATIONS MADE DURING TESTING

[illegible]

BLEMS ENCOUNTERED DURING TESTING

[illegible] with [illegible]

[illegible]

19/10/81

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C.4. 11/1

HOUSE NUMBER
[illegible]
[illegible]

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING

LAB

- Technician [illegible] [illegible] from [illegible] [illegible] disappeared.
(Frances Fullerton)

PROBLEMS ENCOUNTERED DURING TESTING

- Top of Cooking [illegible] [illegible] [illegible] is left open [illegible]
- [illegible] with [illegible] lab while smoking
- [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

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[illegible]

HOUSE NUMBER [illegible]

OBSERVATIONS AND PROBLEMS DURING TESTING

ADDITIONAL OBSERVATIONS MADE DURING TESTING LAB

- had run [illegible] yrs [illegible] [illegible]
- Technician answered questions correctly & appears competent (Walter & Kathleen)
- lab is ~~reasonably~~ [illegible] clean
- lab [illegible] [illegible] [illegible] [illegible] samples properly ✓

PROBLEMS ENCOUNTERED DURING TESTING

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[illegible]

HOUSE NUMBER
Gagn[illegible]

OBSERVATIONS AND PROBLEMS DURING TESTING

ITIONAL OBSERVATIONS MADE DURING TESTING

LAB

– [illegible] Building with [illegible] (Results of [illegible] Study indicated NO EFFECT on [illegible])

BLEMS ENCOUNTERED DURING TESTING

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Oct 21/81

HOUSE NUMBER
Lab

Proctor + Redfor

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OBSERVATIONS AND PROBLEMS DURING TESTING

DDITIONAL OBSERVATIONS MADE DURING TESTING

- Standard Stock Solutions are not stored in refrigerator
- No date on Standard Stock Solution
- Competent

BLEMS ENCOUNTERED DURING TESTING

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HOUSE NUMBER

OBSERVATIONS AND PROBLEMS DURING TESTING

DITIONAL OBSERVATIONS MADE DURING TESTING

Warnock Hersey Professional Services
Antonio Miguel, [illegible]

Oct. 28, 1981.

- no problems with analyses
- analysis area set up on the second floor of a separate part of the building, removed from the main lab
- 1 refrigerator houses the samples only, while a separate refrigerator houses the chemicals in a separate section of the company
- refluxed paraformaldehyde used as standard
  standards prepared fresh daily
- single distilled tap water used for analysis steps - it is distilled in the main lab, filled up in a large glass container and brought [illegible] to an area nearer to the analysis area
- smoking was observed in the offices occupying the same general area as the analysis area.

BLEMS ENCOUNTERED DURING TESTING

Sampling - had problems doing wood-moisture determinations
some probe tips broken (concrete hit)

- house preparation was sometimes a problem since some homeowners did not follow the protocol exactly
- some homeowners did not have UFFI but were on the list

APPENDIX B

Collaborative Laboratory Test Data

Table (1-a)

FIRST ROUND COLLABORATIVE TESTING (A+B)

(STANDARD SAMPLES)

TANDARD AMPLES ug/ml)	A	B	C	D	E	F	G	H	I	K	M	N	O	P	R	S	T	U
0.22 ± 0.03	0.25	0.23	0.13	0.12	0.18	0.07	0.36	0.23	0.18	0.22	0.13	0.15	0.19	0.18	0.10	0.21	0.18	0.17
	0.21		0.14	0.14	0.20	0.08	0.18		0.21		0.13		0.19		0.21			
0.49 ± 0.07	0.52	0.48	0.34	0.42	0.50	0.40	0.68	0.53	0.48	0.52	0.41	0.42	0.49	0.45	0.46	0.47	0.57	0.59
	0.47		0.36	0.30	0.47	0.37	0.46		0.48		0.43		0.51		0.45			
1.12 ± 0.17	1.03	1.11	1.04	0.99	1.24	1.05	1.16	1.23	1.17	1.16	1.08	1.02	1.22	1.11	1.11	1.10	1.15	1.15
	0.98		1.04	0.98	1.25	1.17	1.31		1.18		1.13		1.16		1.06			
1.46 ± 0.22	1.33	1.41	1.40	1.38	1.65	1.13	1.47	1.72	1.45	1.40	1.43	1.36	1.55	2.48	1.46	1.47	1.57	1.58
	1.36		1.35	1.17	1.65	1.57	1.59		1.45		1.47		1.42		1.42			
2.02 ± 0.30	1.68	1.91	2.04	1.93	2.30	2.17	2.09	1.78	2.02	2.04	1.91	2.04	2.16	2.00	1.96	1.97	1.94	2.11
	1.81		1.94	1.84	2.27	2.12	2.05		1.99		2.00		2.09		1.98			
2.24 ± 0.34	2.03	1.97	2.38	2.12	2.53	2.40	2.19	2.38	2.20	2.22	2.19	2.19	2.37	2.26	2.11	2.18	2.36	2.40
	1.90		2.25	2.20	2.54	2.36	2.27		2.20		2.19		2.34		2.14			

A,B = CSC
C,D = Levelton
E,F = Technitrol
G,H = Enviroclean
I,K = Geortec

M,N = Atlantic Analytical
O,P = Proctor & Redfern
R,S = Warnock Hersey
T,U = MacLaren Plan Search (N.S.)

Table (i-b)

SECOND ROUND COLLABORATIVE TESTING (C)

(STANDARD SAMPLES)

STANDARD SAMPLES (ug/ml)	A	B	C	D	E	F	G	H	J	K
1) 0.038 ± .006	-	.037 .038	.036	not reported	.023	.033	0 .024	.06	-	.02 0
2) 0.076 ± .011	.036 .035	.067 .069	.064		.083	.025	.040 .043	.17	.035	.096 .048
3) 0.114 ± .017	.078 .089	0.100 0.100	.083		.149	.105	.140 .096	.21	.06	.104 .072
4) 0.152 ± .023	.138 .128	.140 .140	.140		.174	.152	.198 .136	.22	.133	.116 .100
5) 0.190 ± .029	.171 .173	0.180	.170		.181	.195	.229 .171	.27	.170	.136 .128
6) 0.227 ± .034	.223 .225	.220	.210		.264	.214	.259 .250	.31	.280	.196 .192

A = Technitrol
B,C = Warnock Hersey
D = MacLaren Plan Search (N.S.)
E = Geortec
F = CSC

G = Enviroclean
H = Proctor & Redfern
J = Atlantic Analytical
K = [illegible]velton

Table (i-c)

THIRD ROUND COLLABORATIVE TESTING (D)

(STANDARD SAMPLES)

STANDARD SAMPLES (ug/ml)	A	B	C	D	E	F	G	H	J	K
1) .054 ± .008	-	.038	.024		.015	.02	(.036)	<.01	.18	.016
2) .119 ± .018	.118 .123	.130	.110		.129	.148	.113	.06	.11	.084 .084
3) .289 ± .043	.296 .295	.270	.260		.324	.298	.298	.24	.35	.188 .188
4) .374 ± .056	.476 .476	.430	.420		.505	.395	.570	.43	.58	.336 .3
5) .459 ± .069	.466 .454	.420 .420	.400		.573	.475	.518	.42	.52	.312 .336
6) .497 ± .075	.555 .530	.490 .500	.490		.603	.510	.500	.49	.60	.368 .336

A = Technitrol
B,C = Warnock Hersey
D = MacLaren Plan Search (N.S.)
E = Geortec

F = CSC
G = Enviroclean
H = Proctor & Redfern
J = Atlantic Analytical
K = Levelton

COLLABORATIVE TEST DATA - SPLIT SAMPLES

Table ii (no temperature or pressure corrections)

HOUSE NUMBER (SAMPLE)	LAB RESULT (ppm)	LAB I.D.	CSC (ppm)
2050	.019	1	.011
3688	.013	1	.014
1290	.030	1	.025
1660	.018	1	.019
1604	.012	1	.012
1872	0	1	.005
1696	.024	1	.033
1686	.013	1	.011
1195	.025	1	.020
3793	.013	1	.009
1732	.008	1	.007
3561	.008	1	.013
4585	.049	2	.020
4699	.058	2	.044
4799	.058	2	.092
5020	.028	2	.054
5194	.018	2	.018
5362	.013	2	no sample
5463	.081	2	.075
6051	.018	2	.004
6330	.014	2	.014
5714	.12	2	.112
5612	.095	2	.090
6145	.10	2	.079
5943	.066	3	.078
5725	.042	3	.054
5731	.026	3	.033
4953	.014	3	.026
99-4109	.010	1	.019
846	0	1	.015
4391	.015	1	.025
2095	.028	1	.045
99-2926	.040	1	.054
99-236	.035	1	.044
99-1476	.001	1	.017
2764	.003	1	.013
99-2345	.016	1	.017
1074	.018	1	.020
ACTS-7721	.020	1	.020
99-4515	.011	1	.015
ACTS 4919	.001	1	.014
99-6649	.064	1	.037
99-4640	.012	1	.020
ACTS 582	.017	1	.032
ACTS 8262	.027	1	.023
837	0	1	.020

HOUSE NUMBER (SAMPLE)	LAB RESULT (ppm)	LAB I.D.	CSC (ppm)
591	.077	4	.055
178	.048	4	.047
833	.024	4	0
420	.058	4	.054
418	.058	4	.101
6367-1	.011	5	.008
6367-2	.033	5	.035
6367-3	.024	5	.033
6367-4	.011	5	.008
6563-1	.034	5	.041
6563-2	.034	5	.039
6563-3	.011	5	.009
6563-4	.031	5	.035
6563-5	.013	5	.016
6825-1	.009	5	.003
6825-2	.030	5	.024
6825-3	.004	5	0
6825-4	.022	5	.030
991276-1	.182	5	.105
991276-2	.095	5	[illegible]
991276-3	.028	5	.016
991276-4	.039	5	.015
6492-1	.009	5	.017
6492-2	.084	5	.106
6492-3	.071	5	.072
6492-4	.003	5	.006
5814	.034	2	.029
6600	.016	2	.008
6700	.068	2	.065
7001	.007	2	.003
7200	.020	2	.011
7311	.045	2	.047
7400	.029	2	.027
7500	.008	2	0
7800	.031	2	.025
8009	.003	2	.109
8113	.034	2	0
ACTS-9009	.014	4	.008
309	.007	4	.019
309	.025	4	.010
ACTS 4085	.032	6	.036
CF 198	.034	6	.116

LAB I.D.: Technitrol = 1; Enviroclean = 2; Proctor & Redfern = 3; Atlantic Analytical = 4; Levelton = 5; Geortec = 6

APPENDIX C

Troubleshooting Manual

PREPARED BY CONCORD SCIENTIFIC CORP.

FIELD GUIDE

(i) Equipment Checklist for Formaldehyde Sampling in Homes

(ii) Problems Encountered Most Commonly in the Field.

110.96-80

23 September 81

(i) Equipment Checklist for Formaldehyde Sampling in Homes

Home data packages.

Contact names. Addresses. Telephone numbers. Road map.

Watch. Pens (ballpoint). Tape measure. Scissors. Labels.

Telephone number of nearest weather station (Environment Canada or Transport Canada).

Psychrometer. Table of relative humidity (%) vs T_{wb} and T_{db}.

Anemometer.

Wood moisture meter and probe.

Drill and bit. Extension cord. Ladder (6'). Tape measure.

Draeger pump and kit. Draeger tubes - formaldehyde ($\geq$ 10 per house).
- water vapour ($\geq$ 10 per house).
- ammonia (10 per house).

Safety glasses (for use when breaking tubes).

Inpingers, clean ($\geq$ 4 per house).

Sodium bisulphite absorbing solution (< 1 week old). Dated. Keep cold.

Pipettes, 20 mL, disposable.

Sampling pumps (4 per house).

EITHER Limiting orifice. Extension cord. Pump oil.

OR Spare battery pack. Chargers.

Mass flow meter or Bubble tube assembly, stopwatch.

Tygon tubing, adapted to impinger.

Drying tubes.

Impinger support(s). Weather housing (see figures, pages 25 and 26 in Procedures Manual).

Sample bottles for shipping. Container for sample bottles.
Shrink bands or tape to seal. Parafilm.
Ice pack(s).

Double de-ionized water.
Pasteur pipettes, squeeze bulb.
Kimwipes.

DNPH Absorbing solution for interfering gases ($\leq$ 3 days old).
Cyclohexane / iso-octane organic solution
Pipettes, 10 mL, disposable
Impingers, clean (2).
Sample bottles, Teflon, sealed for shipping.
OR Impinger shipping container.

Passive dosimeters.
Wire or string.

Fungal spore swab kits, fresh media.
Fungal spore deposition plates, fresh media.
Shipping containers.

Flashlight.
Spare batteries for all battery-operated equipment.
Spare stems for impingers.
Small tool kit (screwdriver etc.)

(ii) Problems Encountered Most Commonly in the Field

PROBLEM	SOLUTION
Psychrometer will not operate. (battery operated)	- Replace batteries. Clean battery terminals.
Temperature reading seems low, relative humidity reading high.	- Dry bulb thermometer probably was wetted with wet bulb thermometer. Repeat measurement, ensuring dry bulb thermometer remains dry.
Formaldehyde gas in wall cavities is below the detection limit of the Dräeger (or equivalent) tube.	- This may occur. However, check to be sure that the inner ampoule of each tube is broken before use. Check for leaks in the pump, and ensure that all other manufacturer' instructions have been followed.
Avoiding studs when drilling holes for wall cavity samples.	- Use a stud finder. Or locate stud in relation to electrical (outlet) box.
Sampling pump won't run.	- AC pumps: Check that there is power at the outlet, that plug couplings are tight, that the extension cord is good, and that the pump is turned on. If all else fails, replace pump with spare.

PROBLEM	SOLUTION
	- Battery pumps: Replace battery, if possible. Conduct checks according to maufacturer's recommendations. If all else fails, replace pump with spare.
Sampling pump runs erratically.	- AC pumps: Ensure adequate oil supply in vane pumps. Check for inlet blockage, tube crimping, blockage. - Battery pumps: Ensure full charge in battery. Check for inlet blockag tube crimping, blockage.
Sample is drawn up tubing to pump.	- Check tubing - impinger connection is correct. Check that pump flow rate is as specified (1 Lpm) and sample volume is correct. Ensure that impinger inlet is not blocked. Be sure to use a drying tube (or equivalent) in line between impinger and pump to protect pump from water damage.
Battery sampling pumps do not seem to hold full charge.	- Rechargeable Ni-Cd batteries must be fully run-down before being recharged.

APPENDIX D

Certifications from Consortium

110.96

TECHNITROL CANADA LTD. LTÉE
TESTING LABORATORIES - LABORATOIRE D'ANALYSES
2245 CHEMIN ST-FRANÇOIS ROAD, DORVAL, QUEBEC H9P 1K3 — TEL. (514) 684-5084 TELEX 05-822554

October 13, 1981

Mr. R. Caton
Concord Scientific Corporation
2 Tippett Road
Downsview (Toronto) Ontario
M3H 2V2

Dear Bob,

Please find attached a list of our field, laboratory and office personnel operating for the UFFI project.

We would pleased to provide you with any additional information which you may require.

Sincerely,

T.J. Adley, Ph.D.

TJA:jp

atts.

Personnel who have received the above training are:

FIELD		LABORATORY	
NAME	DATE	NAME	DATE
HARWOOD, Marjory	21/09/81		
LAMBERT, Robert	22/09/81	KOVENSKY, B. M.Sc.P.Chem.	N.A.
MARKELL, Terry Ann	22/09/81	MINEAU-TEES, H.	Feb.1981
RACINE, Jean-Pierre	21/09/81	SELIM, F.	Sept.1981
VERMANDER, Marc	22/09/81	DUONG, N.	Feb.1981
COMTOIS, Maurice	22/09/81	BULKOVSHTEYN, N.	Oct.1,1981
DAIGNAULT, Brian	18/09/81	REA, K.	Oct.6,1981
SELIM, Habib	23/09/81		
THOMAS, Tim Lloyd	24/09/81		
RATHWELL, Kevin	29/09/81		
RAMZANALI, Lakhani	24/09/81		
GALLAGHER, Stephen	28/09/81		
RICART, Patrick	21/09/81		
GINGROW, Pierre-Paul	28/09/81		
KHADIM, M. (Dr.)	25/09/81		
DADI, Salim	24/09/81	OFFICE	
LAVOIE, Gaston	01/10/81	QUARTZ, Denise	Sept.28/81
LAVOIE, Jeanne Dáromde	01/10/81	VAINCOURT, Allison	Sept. 27/81
REITAG, Ronald	03/10/81	SHADLEY, Norma	Sept. 22/81
ARLOW, Steve	05/10/81		
CARLSON, Steve	06/10/81		
TIGANI, Vincent	05/10/81		
KALIL, Michael	03/10/81		
HIRSH, Andrew J.	05/10/81		
POLUD, Joseph	05/10/81		
TEMPLE, Ian	22/09/81		
WATSON, John	25/09/81		
DESROCHERS, L.	(In training)		
DUNSBY, Steven	(In training)		
UPCOTT,Jeff (part-time)	08/10/81		
PELLETIER, France	08/10/81		

I HEREBY CERTIFY THAT THE ABOVE IS A TRUE AND CORRECT LIST OF EMPLOYEES WORKING FOR UFFI.

Thomas J. Adley, Ph.D.

*** CERTIFICATION OF PROFICIENCY ***

The following is a formal certification of proficiency for all field and laboratory technicians, with sampling or analytical responsibilities in the national survey for formaldehyde gas in homes.

The purpose of the formal certification procedure is to provide assurance that these technicians have received training, and have achieved a level of proficiency necessary to conduct their duties thoroughly and correctly.

The Project Manager and/or the Regional Supervisor(s) certify that all technicians working within their area of responsibility have received the training as outlined in the following two pages, by affixing his/their signature(s) at the end of this document.

SCANADA
OCT 20 1981

OCT 7 198

Training Checklist

Field and laboratory technicians have been:-

1) Informed of the aims and objectives of the overall project and their role within it.

2) Given background information on UFFI to enable them to converse with home occupants and respond to questions or concerns in a technically correct manner.

3) Instructed to follow protocols strictly, keep records neatly, and forward results promptly (as indicated on the data sheets provided).

4) Provided with copies (or easy access to copies) of the Procedures Manual, the QA/QC Specifications, and Appendices A and B of the QA/QC Specs.

Field personnel have been:-

5) Instructed on housing construction and the installation of UFFI and how to verify UFFI in wall cavities (as distinguishable from other types of insulation).

6) Instructed on interviewing techniques, so as to obtain information from the homeowner concerning their house preparation methods and their observations of health effects, without leading them in their answers.

7) Instructed on house preparation procedures, sampling methods (as provided in the Procedures Manual and updated from time-to-time in writing by the client and/or QA Supervisor), how to locate sampling points (and why), sample handling, storing and transportation protocols, and record-keeping requirements.

8) Provided with supervised hands-on training at a sampling site.

9) Instructed in calibration, function, maintenance, and safe use of each piece of field equipment.

10) Instructed in potential and common sources of error arising from misuse of the equipment.

11) Instructed in the importance of accurate and complete record-keeping, sample labelling.

12) Examined for proficiency in all of the above, and considered competent to perform field work according to the project requirements.

13) Provided with a copy of the project operational (field) manual developed by the project consortium.

Laboratory personnel have been:-

14) Instructed on preparation and dating of standards, chemical solutions, sample handling procedures, analytical methods (as provided in the Procedures Manual), and record-keeping requirements.

15) Provided with supervised, hands-on training in the preparation of chemical solutions and standards, and in the performance of analyses.

16) Instructed in potential and common sources of analytical errors and their effects on the various parameters.

17) Instructed in the importance of accurate and complete record-keeping, sample labelling.

18) Examined for proficiency in all of the above, and considered competent to perform laboratory work according to the Procedures Manual.

Signed: A Moses (Name) October 19, 1981 (Date)

Proctor & Redfern Ltd.
(Company)

Northern Ontario
(Region - Area of Responsibility)

Personnel who have received the above training are:

FIELD		LABORATORY	
NAME	DATE	NAME	DATE
Jim Burnick	BSc.	Nadine Armstrong	BSc.
Jennifer deBoer	MEng.	Sherry Yacoub	BASc
Sherry Yacoub	BASc	John [illegible]	BSc
Adam Effio	PhD	Dave Kane	PhD
Mike Rogers	BASc	Adam Effio	PhD
Tom Branny	BSc	Mike Rogers	BSc.
Joe Szarig	M Eng P Eng.		
Pat Brouse			
Adele Filson	BA.		

Rec'd 81.10.29
RBC

MacLaren Plansearch

ECONOMIC AND SOCIAL STUDIES
ENVIRONMENTAL SCIENCES
TRANSPORTATION STUDIES
COMPUTER SCIENCE
URBAN AND REGIONAL PLANNING
OCEAN SCIENCE AND OPERATIONS
WATER RESOURCES

MacLAREN PLANSEARCH INC
THE PLANNING AND RESEARCH DIVISION OF LAVALIN
1220 SHEPPARD AVENUE EAST, SUITE 100
WILLOWDALE (METROPOLITAN TORONTO) ONTARIO CANADA M2K 2T8
TELEPHONE (416) 499 0880 TELEX 06 986794 CABLE JAYMAC

34077-0

26 October 1981

Dr. Robert B. Caton
Manager, Toxic Substances
Concord Scientific Corporation
2 Tippett Road
Downsview, Ontario
M3H 2V2

U.F.F.I. Testing Program

Dear Doctor Caton:

Enclosed is the Certification of Proficiency for all field and laboratory technicians working on the U.F.F.I. testing program (400 houses in Ontario Region).

Yours very truly,

MacLAREN PLANSEARCH

J.M. Rigney

J.M. Rigney, P. Eng.
Project Manager

ab

Encl.

cc E. Bonnyman, Scanada

*** CERTIFICATION OF PROFICIENCY ***

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The Project Manager and/or the Regional Supervisor(s) certify that all technicians working within their area of responsibility have received the training as outlined in the following two pages, by affixing his/their signature(s) at the end of this document.

Training Checklist

Field and laboratory technicians have been:-

1) Informed of the aims and objectives of the overall project and their role within it.

2) Given background information on UFFI to enable them to converse with home occupants and respond to questions or concerns in a technically correct manner.

3) Instructed to follow protocols strictly, keep records neatly, and forward results promptly (as indicated on the data sheets provided).

4) Provided with copies (or easy access to copies) of the Procedures Manual, the QA/QC Specifications, and Appendices A and B of the QA/QC Specs.

Field personnel have been:-

5) Instructed on housing construction and the installation of UFFI and how to verify UFFI in wall cavities (as distinguishable from other types of insulation).

6) Instructed on interviewing techniques, so as to obtain information from the homeowner concerning their house preparation methods and their observations of health effects, without leading them in their answers.

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8) Provided with supervised hands-on training at a sampling site.

9) Instructed in calibration, function, maintenance, and safe use of each piece of field equipment.

10) Instructed in potential and common sources of error arising from misuse of the equipment.

11) Instructed in the importance of accurate and complete record-keeping, sample labelling.

12) Examined for proficiency in all of the above, and considered competent to perform field work according to the project requirements.

13) Provided with a copy of the project operational (field) manual developed by the project consortium.

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14) Instructed on preparation and dating of standards, chemical solutions, sample handling procedures, analytical methods (as provided in the Procedures Manual), and record-keeping requirements.

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16) Instructed in potential and common sources of analytical errors and their effects on the various parameters.

17) Instructed in the importance of accurate and complete record-keeping, sample labelling.

18) Examined for proficiency in all of the above, and considered competent to perform laboratory work according to the Procedures Manual.

Signed: ______________________ (Name)

20 October, 1981 (Date)

MacLAREN PLANSEARCH INC.
(Company)

ONTARIO - 400 HOUSES
(Region - Area of Responsibility)

Personnel who have received the above training are:

FIELD		LABORATORY	
NAME	DATE	NAME	DATE
eam Leaders			
I.D. Naraine	6 Oct./81	Wm. Neaves, M.Sc. - Lab Supervisor	Sept./81
J.G. Ashbee	5 Oct./81		
C. Prozowski	13 Oct./81	Cindy Hartman - Technician	Sept./81
J. Dunne	5 Oct./81		
R. Littleproud	5 Oct./81	Laura Weatherston - Technician	6 Oct./81
A. Ciccone	5 Oct./81	Jeanine Waugh - Technican	10 Oct./81
S. Rockel	13 Oct./81		
J. Langan	5 Oct./81	Joyce Hudson - Technican	15 Oct./81
L. Manley	6 Oct./81		
W. Cormack	5 Oct./81		
L. Chow	5 Oct./81		
echnicians			
J. Doan	13 Oct./81		
B. Heine	19 Oct./81		
A. Poynton	5 Oct./81		
J. Savel	5 Oct./81		
D. Golan	5 Oct./81		
K. Thatcher	5 Oct./81		
P. Cosburn	19 Oct./81		
J. Tost	16 Oct./81		
P. Donahue	16 Oct./81		
T. Perry	5 Oct./81		
G. MacDougall	16 Oct./81		

Scanada

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OCT 7 198

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8) Provided with supervised hands-on training at a sampling site.

9) Instructed in calibration, function, maintenance, and safe use of each piece of field equipment.

10) Instructed in potential and common sources of error arising from misuse of the equipment.

11) Instructed in the importance of accurate and complete record-keeping, sample labelling.

12) Examined for proficiency in all of the above, and considered competent to perform field work according to the project requirements.

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16) Instructed in potential and common sources of analytical errors and their effects on the various parameters.

17) Instructed in the importance of accurate and complete record-keeping, sample labelling.

18) Examined for proficiency in all of the above, and considered competent to perform laboratory work according to the Procedures Manual.

Signed: (Name) Oct. 20/81 (Date)

SCANADA CONSULTANTS
(Company)

EASTERN ONT.
SOUTHERN ONT.
(Region - Area of Responsibility)

Personnel who have received the above training are:

FIELD		LABORATORY	
NAME	DATE	NAME	DATE
A. CAMERON	SEPT 1		
M. GARDNER	OCT. 6		
S. SAMSON	SEPT 24		
R. MOORE	OCT. 15		
G. ROCKLEY	SEPT 19		
J. KINGSWOOD	SEPT 24.		
P. KNOX	SEPT 24		
I. MacDONALD	OCT. 6		
K. SPARFEL	SEPT 24		
C. FERGUSON	OCT. 6		
D. LENAHAN	SEPT 1.		
K. RUEST	SEPT. 1.		

Training Checklist

Field and laboratory technicians have been:-

1) Informed of the aims and objectives of the overall project and their role within it. ✓

2) Given background information on UFFI to enable them to converse with home occupants and respond to questions or concerns in a technically correct manner. ✓

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5) Instructed on housing construction and the installation of UFFI and how to verify UFFI in wall cavities (as distinguishable from other types of insulation). ✓

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9) Instructed in calibration, function, maintenance, and safe use of each piece of field equipment. ✓

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11) Instructed in the importance of accurate and complete record-keeping, sample labelling. ✓

12) Examined for proficiency in all of the above, and considered competent to perform field work according to the project requirements. ✓

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Laboratory personnel have been:-

14) Instructed on preparation and dating of standards, chemical solutions, sample handling procedures, analytical methods (as provided in the Procedures Manual), and record-keeping requirements. ✓

15) Provided with supervised, hands-on training in the preparation of chemical solutions and standards, and in the performance of analyses. ✓

16) Instructed in potential and common sources of analytical errors and their effects on the various parameters. ✓

17) Instructed in the importance of accurate and complete record-keeping, sample labelling. ✓

18) Examined for proficiency in all of the above, and considered competent to perform laboratory work according to the Procedures Manual. ✓

Signed: ______________________ (Name) 10 October 1981 (Date)

GEORTEC LTD

(Company)

NEWFOUNDLAND/P.E.I

(Region - Area of Responsibility)

SUBCONTRACTORS: NOVA SCOTIA : MACLAREN PLANSEARCH
NEW BRUNSWICK: ATLANTIC ANALYTICAL

Personnel who have received the above training are:

FIELD		LABORATORY	
NAME	DATE	NAME	DATE
DAVID SNOW		DAVID SNOW	
RUTH McLAGAN	GEORTEC	RUTH McLAGAN	
DAVID TAYLOR	PERSONNEL		
CALLUM THOMSON			

D-20
1981

Training Checklist

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9) Instructed in calibration, function, maintenance, and safe use of each piece of field equipment. ✓

10) Instructed in potential and common sources of error arising from misuse of the equipment. ✓

11) Instructed in the importance of accurate and complete record-keeping, sample labelling. ✓

Atlantic Analytical Services Ltd
275 CITY ROAD.
SAINT JOHN
NEW BRUNSWICK

Canadian Scientific Corporation

Personnel who have received the above training are:

FIELD		LABORATORY	
NAME	DATE	NAME	DATE
ROLAND GARVIE.	2/11/81	ROLAND GARVIE	2/11/81
GREGORY KIERVIN	2/11/81	CLIFFORD RAYMOND	2/11/81
PHILIP MORRISON.	2/11/81	FRANCIS FULLERTION	2/11/81.
FERNAND PELLETIER.	2/11/81		
NEIL MORRISON	2/11/81		
MICHAEL DOW.	2/11/81		
SCOTT BRANSTON.	2/11/81		
MARK NAGLE.	2/11/81		

*** CERTIFICATION OF PROFICIENCY ***

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Training Checklist

Field and laboratory technicians have been:-

1) Informed of the aims and objectives of the overall project and their role within it. ✓
2) Given background information on UFFI to enable them to converse with home occupants and respond to questions or concerns in a technically correct manner. ✓
3) Instructed to follow protocols strictly, keep records neatly, and forward results promptly (as indicated on the data sheets provided). ✓
4) Provided with copies (or easy access to copies) of the Procedures Manual, the QA/QC Specifications, and Appendices A and B of the QA/QC Specs. ✓

Field personnel have been:-

5) Instructed on housing construction and the installation of UFFI and how to verify UFFI in wall cavities (as distinguishable from other types of insulation). ✓
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8) Provided with supervised hands-on training at a sampling site. ✓
9) Instructed in calibration, function, maintenance, and safe use of each piece of field equipment. ✓
10) Instructed in potential and common sources of error arising from misuse of the equipment. ✓
11) Instructed in the importance of accurate and complete record-keeping, sample labelling. ✓

12) Examined for proficiency in all of the above, and considered competent to perform field work according to the project requirements. ✓

13) Provided with a copy of the project operational (field) manual developed by the project consortium.

Laboratory personnel have been:-

14) Instructed on preparation and dating of standards, chemical solutions, sample handling procedures, analytical methods (as provided in the Procedures Manual), and record-keeping requirements. ✓

15) Provided with supervised, hands-on training in the preparation of chemical solutions and standards, and in the performance of analyses. ✓

16) Instructed in potential and common sources of analytical errors and their effects on the various parameters. ✓

17) Instructed in the importance of accurate and complete record-keeping, sample labelling. ✓

18) Examined for proficiency in all of the above, and considered competent to perform laboratory work according to the Procedures Manual. ✓

Signed: A. J. Shaw (Name) 29 oct 81 (Date)

B. H. Levelton & associates Ltd
(Company)

B. C., Alberta, Saskatchewan, Manitoba
(Region - Area of Responsibility)

Personnel who have received the above training are:

FIELD		LABORATORY	
NAME	DATE	NAME	DATE
B. H. LEVELTON & ASSOC		B. H. LEVELTON & ASSOC	
TOM COTTON.	Sept 23-25/81	JOE WEHLE.	Sept 23-25/81
VERA CERMETIC	"		
NORM JUNG.	"	NORMA GINTHER.	oct 6/81
AL. ELANDER.	oct 6/81		
BRIAN BLAKE.	"	ROB GROVES.	oct 6/81
GRAIG WOODFIELD	"		
HAROLD McLEAN	Sept 23-25/81		
BOB COCHLAN	"		
BEAK CONSULTANTS LTD (VAN)			
AL LANFRANCO	oct 6/81		
ROB MAC KAY.	"		
BILL QUIGLEY.	"		
TIM REDEKOP	"		
NATIONAL TESTING. LABS (W.M.)			
DON FLATT.	oct 14/81		
ROB BILBEY	"		
GRANT Mc VICAR.	"		
BRAD BOUCHER	"		
CON. DODYKEVICK.	"		

D-25 NOV 12 1981 REC'D

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Required by
QC/QA
letter Sept 22/81

Training Checklist

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5) Instructed on housing construction and the installation of UFFI and how to verify UFFI in wall cavities (as distinguishable from other types of insulation).

6) Instructed on interviewing techniques, so as to obtain information from the homeowner concerning their house preparation methods and their observations of health effects, without leading them in their answers.

7) Instructed on house preparation procedures, sampling methods (as provided in the Procedures Manual and updated from time-to-time in writing by the client and/or QA Supervisor), how to locate sampling points (and why), sample handling, storing and transportation protocols, and record-keeping requirements.

8) Provided with supervised hands-on training at a sampling site.

9) Instructed in calibration, function, maintenance, and safe use of each piece of field equipment.

10) Instructed in potential and common sources of error arising from misuse of the equipment.

11) Instructed in the importance of accurate and complete record-keeping, sample labelling.

12) Examined for proficiency in all of the above, and considered competent to perform field work according to the project requirements.

13) Provided with a copy of the project operational (field) manual developed by the project consortium.

Laboratory personnel have been:-

14) Instructed on preparation and dating of standards, chemical solutions, sample handling procedures, analytical methods (as provided in the Procedures Manual), and record-keeping requirements.

15) Provided with supervised, hands-on training in the preparation of chemical solutions and standards, and in the performance of analyses.

16) Instructed in potential and common sources of analytical errors and their effects on the various parameters.

17) Instructed in the importance of accurate and complete record-keeping, sample labelling.

18) Examined for proficiency in all of the above, and considered competent to perform laboratory work according to the Procedures Manual.

Signed: Don Flatt (Name) Oct 15/81 (Date)

National Testing Laboratories Limited (Company)

Manitoba (Region - Area of Responsibility)

Technicians - Grant McVicar
Rob Bilbey
Brad Boucher
Con Bodykevich

APPENDIX E

Miscellaneous Documents

REGIONAL SUPERVISORS - QA/QC
WEEKLY DATA SUMMARY

DATE: ____________________
(Oct 5, 12, 19, 26, Nov 2)

Region: ____________________ Contact: ____________________

Time Period (Mon. - Sat.): ____________________

Sampling Completed (during above period)

Number of Homes Sampled: ____________________

Number of Sample Locations (Revised NIOSH): ____________________
Number of Replicate Pairs : ____________________
Number of Blanks : ____________________
TOTAL : ____________________

Analyses Completed (during above period)

Number of Analyses (Revised NIOSH) - TOTAL: ____________________
Number of Replicate Pairs : ____________________
Number of Blanks : ____________________
Number of QA Samples : ____________________

Replicate Pairs (x_1 and x_2)	Blank Values	Room Air (C_{TWA}): Wall Cavity (C_{ST})
$\frac{x_2 - x_1}{x_1} \times 100\% > 15\%$	>0.5 µg HCHO (working aliquot)*	$C_{TWA} > 1/5\ C_{ST}$ OR $< 1/60\ C_{ST}$
Total Number:____	Total Number:____	Total Number:____
House ID Numbers:	House ID Numbers:	House ID Numbers:

---

* 0.5 µg/4 ml. · 0.13 µg/mL
1 µg/8 ml.

Signature: ____________________

Our Ref: 110.96-80

Dear

Reference: National Survey For Formaldehyde Gas In Homes - Quality Assurance Procedures

---

Laboratories participating in the national survey are required to take part in several procedures outlined in the QA/QC Specifications Manual of that project. These are summarized below.

An analytical collaborative study will be conducted among participating labs during the first week of their involvement in the project. This is to consist of six formaldehyde standard samples for analysis by the revised NIOSH method (See Procedures Manual, Appendix B-1).

Enclosed are these six samples for analysis. Each sample is comprised of two 50-mL Nalgene bottles (L.P.E.) of solution which are to be kept refrigerated. The solutions have been made up gravimetrically as primary standards from crystalline sodium formaldehyde bisulfite (Kodak P6450, Lot A1A) in 1% $NaHSO_3$/organic-free, deionized water. Concentrations are within the normal working range of the NIOSH method.

One bottle of each sample is to be used for duplicate analyses on Day 1 by the primary technician(s) assigned to the project. The second bottle of each sample is to remain sealed and refrigerated until Day 2, when the six samples are to be analyzed once by either the same technician(s) as on Day 1 or other technicians involved in the project.

Four mL aliquots should be used, as in the normal NIOSH procedure.

The total number of analyses required is 18.

The results are to be reported on the enclosed form and, together with the standard curve (numerical values for x, y shown at each point), returned promptly to the QA Supervisor at the above address. This completes the first project QA requirement.

A second analytical collaborative study will be conducted among participating labs during the first three weeks of October. Standard samples will be sent to you at a rate of approximately three per week. We request your cooperation in adding these samples to your normal analytical load, such that they are indistinguishable from field samples (sample identification may require adjustment for that purpose).

The results from these samples are to be reported weekly on a "Lab Reporting Data Sheet", copies of which are contained in the project data sheet packages supplied by the client and which are used for reporting the results of all formaldehyde (by the revised NIOSH method) results. These results are to be returned promptly to the QA Supervisor at the above address. This will complete the second project QA requirement.

During the course of the study, 1% of all NIOSH impinger samples received by the laboratory are to be split for duplicate analysis by the QA laboratory. These are to be sealed in Nalgene bottles, refrigerated, and sent on a weekly basis to the above address. It is expected that this will amount to six to ten duplicates per lab per week. This will complete the third project QA requirement.

Throughout the study, sample blanks and field replicates will be submitted by the field teams for analysis. These samples will be indistinguishable from normal field samples. They will only be identified and their results reviewed at the levels of the Local Project Supervisor, Project Manager, or QA Supervisor. This constitutes the fourth project QA requirement. Should any samples received from your field teams be identifiable in any way as to whether they are blanks or replicates, please inform the Local Project Supervisor and the QA Supervisor.

Your cooperation in these procedures is appreciated. Should you have any questions concerning any of the above, I would be pleased to respond, or contact Mrs. Joanne Lux, Laboratory Manager.

Sincerely,

CONCORD SCIENTIFIC CORPORATION

ROBERT B. CATON, Ph.D.
Director Toxic Substances

RBC/lb

Collaborative Formaldehyde Analysis Data Sheet

NIOSH Revised Method

Date of Analysis: ____________________

Sample Number	Absorbance	Formaldehyde Concentration (ug/ml)

Standard Curve Attached (   ) include (x,y) values at each point.

Instrument: ____________________

Wavelength, nm: ____________________

Path Length, cm: ____________________

Stock Formaldehyde Concentration: ____________________

Solution Matrix: ____________________

Comments:

Laboratory: ____________________

Signature: ____________________ Date: ____________

September 28, 1981

Our Ref: 110-96

Dr. T.J. Adley
Technitrol Canada Ltee
2245 St. Francois Road
Dorval, Quebec
H9P 1K3

Dear Mr. Adley:

Re: QA on national formaldehyde survey

This is to clarify and confirm several points regarding the revised NIOSH analysis method.

1. Sensitivity. The determining factor is the quantification limit expressed as a number of absorbance units above the blank absorbance. The NIOSH criterion is 0.05 AU above blank. We recommend retaining this criterion, which corresponds to an analytical precision of ± 5 % (NIOSH).

In this case, we calculate that the quantification limits corresponding to various absorption path lengths are as follows, based on data from our laboratory:

Path	MQA[a]	Detection Limit(ppb)[b]			Blank (AU)[c]
		60L	120L	180L	
1 cm	1 µg	86 ppb	43 ppb	29 ppb	0.01 - 0.02 AU
2 cm	0.6	48	24	16	0.02 - 0.04
4 cm	0.4	36	18	12	0.04 - 0.08
5 cm	0.3	26	13	9	0.05 - 0.10

.../2

Concord Scientific Corporation

Notes:

a) Minimum quantifiable amount (at 0.05 AU above blank) in 4 mL working aliquot taken from total impinger solution volume made up to 25 mL. (aliquot factor = 25/4).

b) 1 ppbv (HCHO) = 0.0012 µg/L of air sampled

c) Typical blank values extrapolated from our data for 1 cm path.

d) Volume of air sampled at 1 Lpm through liquid-filled impinger (1% Na HSO_3)

2. Sampling period. In order to use a 2-hour sampling period (120 L sample) and achieve a quantification limit of at least 20 ppb (0.02 ppm), a path length of 4 or 5 cm is required, based on the above table. Samples with sufficient optical density, of course, may be run in shorter path length cells, at the discretion of the laboratory.

3. Reporting. Results may actually be determined for absorbances down to, say, 0.01 AU above blank. Values less than the quantification limit (i.e., the limit corresponding to acceptable precision and accuracy) should be reported but written in parentheses.

   The working quantification limit will vary slightly from day to day and lab to lab and should be recorded on lab data sheets (as determined from the day's standard curve and blank values).

4. Variance from above requirements. It may be difficult for all of your participating laboratories to procure the necessary equipment to meet these specifications in time to be of use to the survey. Every effort should be made to meet them, however, within your constraints.

5. Solution volumes. In order to fill standard 4 or 5 cm cuvettes to the required level, it will be necessary to scale up the portions of NIOSH reagents (impinger aliquot, sulphuric acid and chromatropic acid) appropriately. There appears to be no reason why this procedure would not yield equivalent results, as long as the colour development time and temperature are maintained as specified. Semi-micro cuvettes will work with the original portions.

I would be pleased to discuss problems with any of the participating laboratories.

Yours truly,

CONCORD SCIENTIFIC CORPORATION

ROBERT B. CATON, Ph.D.
Director Toxic Substances

RBC/cg

cc: Consortium Members
UFFI Centre (D. [illegible])

File 110.96.

September 24, 1981

Dr. Thomas Adley
Technitrol Canada Ltee
2245 St. Francois Road
Dorval, Quebec
H9P 1K3

Dear Dr. Adley:

Re: National Survey - Formaldehyde in Homes

As discussed in Ottawa on September 18 and by telephone on September 22, I am writing to clarify a number of points on the quality assurance program.

1. The first set of standard samples to be analyzed in the collaborative testing was sent to Teghnitrol and Levelton by courier on September 23. Instructions were given for handling these samples.
T They should be analyzed as soon as possible.

2. Sets of standard samples will be sent out to additional laboratories as they come on-stream.

2.3 All laboratories will receive additional standard samples at the rate of three per week for the first three weeks of October, as indicated in our letter to the receiving laboratories.

4. Copies of the training certification form, the required weekly data summary form and a brief trouble-shooting manual are attached.

5. Replicate sampling by your technicians is to be carried out as follows, which is according to our discussion of September 18:

   a) Each technician (or technician team) is to collect a replicate sample alongside one of the two indoor NIOSH samples in one-half of the UFFI houses tested during the team's first week in the field, or five replicate samples in UFFI houses during the first weeks.

   b) The results of these samples are to be compared according to the criterion specified, that is, for replicate pairs x_1 and x_2 $(x_2 \geq x_1)$,

$$\frac{x_2 - x_1}{x_1} \times 100 > 15\%$$

will flag an undesirable result.

c) Teams not meeting this criterion should collect five more replicate samples in UFFI houses during the second week.

d) The results of all of these tests will be assessed to determine the performance of the corresponding field and laboratory personnel. The feasibility of the criterion will be reviewed at this point (roughly two weeks into the survey).

e) Field teams should continue thereafter to collect replicate samples at the rate of 10% of NIOSH samples. At two NIOSH indoor tests per home and ten UFFI homes per week per team, this means that two replicates would be collected during a normal full working week.

6. 10 mL aliquots of the NIOSH impinger samples taken after dilution to the standard 25 ml as specified in the analytical method should be sent weekly to us for duplicate analysis (about 1% of all NIOSH analytical samples, indluding blanks and replicates). Actual aliquot factors should be supplied with each duplicate sample. These samples should be shipped with freezer cooler packs as supplied with the standard samples for the collaborative tests.

We shall be discussing these points further as the project progresses.

Very truly yours,

CONCORD SCIENTIFIC CORPORATION

ROBERT B. CATON, Ph.D.
Director Toxic Substances

RBC/ems

Attach.

Concord Scientific Corporation
2 Tippett Road, Downsview (Toronto), Ontario, Canada M3H 2V2
Tel: (416) 630-6331

QA/QC CONTRACTOR'S REPORT

The following items were reported orally by R. B. Caton at the progress meeting on 81.10.09 at the UFFI Centre:

1) First-round interlaboratory colloborative test results for three laboratories were reported and a copy of preliminary statistics given to Dr. Maher. The labs were Levelton, Technitrol and Enviroclean (MacLaren) in addition to Concord.

Results were generally within 10% of the standard values, except near the nominal detection limit of the NIOSH method.

2) QA contractor had audited eight field teams in Hamilton and Montreal and two laboratories (Technitrol and Enviroclean) to date. Six sets of replicate field samples had been collected by QA teams.

The major observations in the field (all reported to local supervisors immediately) were:

- misunderstanding of NIOSH sample height
- failure to rinse NIOSH impringers properly
- some teams not doing field blanks

The major lab observations were:

- smoking allowed in Technitrol lab

3) QC weekly reports

- Levelton, Scanada, Technitrol, Geortec surveyed re internal replicate performance, field blanks and Drager/NIOSH comparison, but no quantitative data were forthcoming except for number of homes treated and number of analyses performed.

4) No technician certifications had been returned to QA/QC contractor.

5) No duplicate sample splits had been received to date - about 20 expected to date.

6) No copies of data sheets had been received.

7) Second round interlaboratory colloborative testing would consist of six samples prepared from sodium formaldehyde bisulphite and six prepared from refluxed paraformaldehyde.

8) Questions had arisen in the field concerning the source of water to be used for NIOSH tests (and analysis). It was suggested that deionized/organic - free water should be used, but that it was more important to have a consistant supply, as long as the analytical blanks met the specifications.

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QA/QC CONTRACTOR'S REPORT

The following items were reported orally by R. B. Caton at the progress meeting on 81.10.16 at the UFFI Centre:

1) By Saturday, Oct. 17, replicate sampling would have been carried out in five additional homes (and two or three additional team audits). Three additional laboratories would have been inspected in the Atlantic Region. Teams and labs: Geortec, Atlantic Analytical Services and MacLaren (Dartmouth).

2) Colloborative testing - full reports on first-round collaborative testing had been received from Geortec and Levelton.

First-round samples had been sent to Warnock-Hersey and Proctor and Redfern, completing distribution to all eight participating laboratories.

Second round samples had been sent out to six laboratories (all except the two above)

Results of colloborative testing to date indicated Geortec to be most accurate and precise and Levelton to be least accurate and precise.

3) QC weekly summary was being compiled on Oct. 16.

4) Only Technitrol had submitted technician training certification.

5) No duplicate sample splits had been received. Levelton had informed QA that some had been shipped by air freight on Oct. 13.

6) No copies of data sheets had been received.

7) Field observations (all reported to local supervisors immediately)

- flow calibration problems
- Concord measured flow by means of portable mass flowmeter (secondary standard)

Flow rates ranging from 0.65 to 2.2 Lpm had been measured at various sites in Nova Scotia and New Brunswick. General problems were observed in these areas in setting and maintaining rotameters. Some rotameters (N.S. and N.B.) had not been calibrated - manufacturer's nominal settings were used.

Flow rate problems were not found in Newfoundland.

An apparently serious problem was flagged.
One team in Moncton did not know how to operate the Drager system properly.

R.B.C.
81.10.16

Concord Scientific Corporation
2 Tippett Road, Downsview (Toronto), Ontario, Canada M3H 2V2
Tel: (416) 630-6331

QA/QC CONTRACTOR'S REPORT

The following items were reported orally by R. B. Caton at the progress meeting on 81.10.23 at the UFFI Centre:

1) Homes tested by QA/QC to date
Parallel sampling in 3618, 99-3056, 99-3287, 99-3289, 589, ACTS-8065, ACTS-4588, ACTS-2724, ACTS-7934, 4035, 99-4943, 82
Audit only - 3703, 3640, 99-4457, ACTS-7330.

2) Labs inspected to date

Technitrol, Enviroclean (MacLaren), Levelton, Geortec, MacLaren (Dartmouth), Atlantic Analytical

3) Complete colloborative testing results had been received from all eight labs. A copy of the results was provided to Dr. Maher. The mean result was within 5% of the standard values for five of the six samples.

Only the lowest concentration (at the nominal limit of the method) deviated in the mean by more than 5% from the standard value (18% low).

It is concluded that the overall performance of the participating analytical laboratories is within the specifications.

4) Duplicate sample splits had been received from Technitrol (12) and Enviroclean. Levelton's never arrived (sent on Oct. 13). About 20 out of the anticipated 100 split samples had been received. Concord's results on Technitrol's samples indicated no significant differences.

5) Additional technician training certifications were received from Scanada and Proctor and Redfern.

6) Remaining QA/QC schedule:

Homes

Oct. 22	Regina (2)
Oct. 23	Toronto (2)
Oct. 24	Winnipeg (2)
Oct. 26,27	Oshawa/Toronto (2)

Labs (by Oct. 28)

Warnock Hersey
Proctor and Redfern

Parallel sampling of 20 homes (20 different teams) would be completed by Oct. 28.

Results for only one pair of parallel (replicate) samples were available (House #32 - Geortec). One result was close (0.067, 0.063); one was not (0.091, 0.063), so that no conclusion could be drawn about replicate performance on the whole.

7) Field observations (all reported to local supervisors)

- the problem of operating the Drager system was observed again in New Brunswick (a second team)- xylene ampoules were not being broken
- wide variations in flow rates were again observed at New Brunswick sites
- problems were not observed in field or lab on the West Coast.

8) All eight labs had received 12 second-round collaborative test samples - no results had been reported.

...2

9) Copies of data sheets had been received from Scanada (about 150) and MacLaren - Ontario (35).

R.B.C.
8[illegible]0.23

KBC

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QA/QC CONTRACTOR'S REPORT

The following items are current to Friday, October 30, 1981:

1) QA audits were carried out in the following homes, representing 25 different sampling teams:

Replicate sampling and team audit (20):
3618, 99-3056, 99-3287, 99-3289, 589, ACTS-8065, ACTS-4588, ACTS-2724, ACTS-7934, 4035, 99-4493, 82, 4006, 99-2728, 6792, 6679, 6056, 6233, 7697, 3210

Laboratory results are complete for these homes (to be provided in QA/QC final report).

Team audit only (5): 3902, 3703, 3640, 99-4457, ACTS-7330

2) All 8 participating laboratories had been inspected as of October 28.

3) Second-round collaborative test results have been received from Enviroclean (MacLaren, Ontario) Geortec, Warnock Hersey, Technitrol, and Proctor and Redfern (to be listed in QA/QC final report).

4) Duplicate sample splits had been received from Technitrol, Enviroclean and Proctor and Redfern.

46 out of a total expected of about 100 have been received to date.

Results of the analysis of these samples are in generally very good agreement with those of the originating laboratory (to be provided in QA/QC final report).

5) Additional data sheets were received from MacLaren (Ontario) for about 45 homes.

A total of about 310 sets of data sheets had been received out of the 2300 expected.

Scanada - 141
MacLaren (Ontario) - 80
Geortec - 89

6) Internal QC data summaries polled by telephone on October 29 produced the following results:

Geortec:
data sheets and standard sample results being delivered by courier; certifications in mail; sample plits will follow; including Atlantic Analytical Services and MacLaren (Dartmouth).

QC summaries up-to-date for Atlantic Analytical and Geortec only; no QC summaries for MacLaren (Darmouth)

Technitrol:
no QC summaries available (promised for Nov. 3) [including Warnock Hersey].

Scanada:
no QC summary available

Levelton [including National Testing Laboratories and Beak (Calgary)]:
no QC summary available

7) Technician training certifications have been received from: Technitrol; Scanada; Proctor and Redfern; MacLaren (Ontario, incl. Enviroclean).

Number/
Numéro

7

Annexe 7

ISSN 0701-5216

BUILDING PRACTICE NOTE

BIBLIOT
MINISTÈRE DE LA CONSOMMATION
ET DES CORPORATIONS

UREA FORMALDEHYDE FOAM INSULATION:

PROBLEM IDENTIFICATION AND REMEDIAL MEASURES FOR WOOD-FRAME CONSTRUCTION

by

R.P. Bowen, C.J. Shirtliffe and G.A. Chown

Division of Building Research, National Research Council of Canada

Ottawa, August 1981

NO. 23

National Research Council Canada
Conseil national de recherches Canada

PREFACE

This is the second Building Practice Note on urea formaldehyde foam insulation (UFFI) to be issued by the Division of Building Research, National Research Council of Canada. The first, "Urea Formaldehyde Foam Insulation," BPN 19, is recommended as a general overview of the product and potential problems.

This document has been prepared to meet the demand by consumers and contractors for guidance in solving problems related to UFFI. The need to provide immediate information has not allowed for intensive research or extensive field trials of the remedial measures presented. The properties of the UFFI in a particular house, the sensitivity of the occupants, and the building characteristics will all affect the potential for or the type and severity of problems. It is stressed that no two houses, occupants or UFFI installations are likely to be the same and therefore the success of remedial measures will vary. The remedial measures presented are based on the current knowledge of the behaviour of UFFI and on building science principles. Application of the remedial measures to the wide variety of houses experiencing problems is limited. The procedures may be simplified or supplemented for one or more types of construction as experience is gained and more information becomes available.

The effects of seasonal changes in weather conditions on the performance of the many formulations of UFFI in relation to the formaldehyde and other gas concentrations in the living space are not yet fully understood. In relating the extent of remedial measures to measurements, every attempt has been made to err on the safe side. If doubt remains as to the seriousness of a situation, additional measures should be undertaken. In some cases the services of a consulting engineer or architect will be required to assist in diagnosing a problem and selecting remedial measures.

The term "formaldehyde gas," as used in this document, refers to the mixture of gases released by UFFI; formaldehyde gas is usually dominant. Since this composition of gases may vary from product to product the gas is difficult to characterize and might be called "UFFI gas." For simplicity, the gas is referred to as "formaldehyde gas" but it should not be assumed that it is the same as pure formaldehyde gas or that the limits for exposure are necessarily the same as for the pure gas. As no animal exposure tests have been conducted on "UFFI gas" it would be prudent to keep exposures well below the maximum exposures for pure formaldehyde gas. The recommended minimum remedial measures are based on the dominant gas, formaldehyde. The majority of these measures should, however, reduce the infiltration of "UFFI gas" into the living space.

The examples presented in Appendix A are based on a number of actual cases, but have been simplified to illustrate the use of the remedial measures outlined in the tables.

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UREA FORMALDEHYDE FOAM INSULATION

Problem Identification and Remedial Measures For Wood-Frame Construction

by

R.P. Bowen, C.J. Shirtliffe and G.A. Chown

The National Research Council of Canada and any person acting on its behalf assumes no liability arising from the use of the information contained in this document nor warrants that such use will be free from privately owned rights.

1.0 INTRODUCTION

Urea formaldehyde foam insulation (UFFI) is a foamed-in-place material which has been used primarily for retrofitting residential buildings. In some but not all homes with UFFI, there is evidence of formaldehyde gas emissions from the insulation and fungal growth in the insulated cavities. In some of these homes, one or more household members have experienced adverse health effects believed to be related to the presence of the UFFI. The presence of UFFI in the building enclosure does not mean that the foam has caused or will cause either excessive formaldehyde gas emission or fungal growth. Occupants of homes insulated with UFFI who suspect that problems already exist, anticipate problems because of faulty application, or who just want to have the performance of the material investigated, should have their houses checked. Remedial or preventive measures should be undertaken to reduce the severity of existing problems or reduce the possibility of future ones developing. All measures taken should be documented (including photographs) for future reference.

This publication discusses some procedures that may be followed by the homeowner, contractor, or UFFI manufacturer in diagnosing the conditions in a home and identifies some measures that are remedial or preventive in nature. To date, experience with diagnostic procedures, and remedial and preventive measures has been somewhat limited. Because of the prevalence of wood-frame construction in Canada, the remedial measures discussed here are related only to this type of building. The principles described for both diagnostic and remedial measures, however, can be applied to other types of construction such as masonry. At present, the removal of UFFI from masonry cores or cavities is unlikely to be either effective or feasible. Other remedial measures may have to be selected until new methods of removal are developed.

The magnitude and type of problem encountered, as well as the sensitivities of the occupants, will be factors in the selection and extent of remedial measures used for a particular house. Each house and problem will be unique in some aspects and must be thoroughly investigated before initiating remedial measures. Constant vigilance must be maintained for extenuating factors that might necessitate changing the procedures.

The investigation should include measurements of the formaldehyde gas concentration in the insulated cavities and, when applicable, in the living space, and the moisture content in a series of wall cavities. These and other investigatory procedures are discussed in Section 2. In some cases the measurements are repeated during or after the remedial measures to provide an indication of the effectiveness of the measures.

Remedial measures for wood-frame construction range from increasing the fresh air supplied to the living space to removal of the UFFI. These measures are described in detail in Section 3. In most cases a series of remedial measures is recommended. For a specific house, the selection of the appropriate action steps will be determined by 1) the problems which have been identified such as odour or medical symptoms, and 2) the results of measurements carried out in the investigation. Appendix A provides an outline, in Tables A-1 to A-4, of the action steps and remedial measures which correspond to the various problems and measurements. The recommended remedial measures are the minimum measures that will reduce the formaldehyde gas concentrations (resulting from the UFFI) in the living space. The reduction in formaldehyde gas concentration achieved by the measures will vary. In some cases after the remedial measures are complete, further measurements are recommended. The services of a consulting engineer or architect with a knowledge of UFFI and building construction may be required in some instances to assist in analysing the problem and selecting the appropriate remedial measures.

Where health problems exist, a full medical assessment of the occupants is advised. Decisions as to the remedial measures should take into account the range of susceptibilities of all persons in the household.

For those homes where there are no serious problems related to the presence of the UFFI, minimum preventive measures are suggested to reduce the potential for serious problems occurring in the future. These are discussed in Section 4.

In view of the sensitivities some persons may have to formaldehyde, persons involved in removal of UFFI should exercise proper safety precautions. The wearing of goggles, dust masks, and appropriate clothing is discussed in Section 5.

There are a number of subjects related to identifying and solving UFFI problems which could not be covered in detail in this publication because development of the information is still in progress. Brief summaries have been included in Appendix B and reference made to them in the text.

2.0 PROBLEM IDENTIFICATION

2.1 Medical Symptoms

The health problems caused by exposure to formaldehyde gas in air include eye, nose and throat irritation, coughing, headaches, dizziness, and, in very high concentrations, bronchopneumonia and pulmonary oedema (1). When any of these symptoms are encountered, a doctor should be consulted to determine the cause or to advise the patient on the likelihood that the symptoms are related to the presence of UFFI. A specialist may be required to identify the possible causes of the symptoms.

The doctor should be informed of the patient's history of exposure to UFFI, formaldehyde gas and other chemicals or pollutants both at home and work. Exposure to high concentrations of the gas, as evidenced by strong odours that may have occurred for a time after the installation of UFFI, repeated physical contact with the UFFI, especially when wet, contact with the liquid components, or breathing of formaldehyde dust particles may have initiated a sensitivity to formaldehyde.

If investigations fail to find a correlation between a health problem and exposure to formaldehyde gas, but there appears to be a correlation with the environment in the house, the insulated cavities should be checked for the presence of fungi. The actual reaction of the patient to fungi will depend upon the pathological potential of the individual species and whether spores are present in the air of the living space. Although most fungi are benign, others are known to cause reactions or disease in some people. Many fungi induce respiratory sensitization in susceptible individuals; subsequent exposures can then provoke an asthmatic attack.(2) A list of fungi that have been found to be associated with UFFI is contained in Appendix C. Further discussion of fungal growth is presented in Section 2.3.

Persons who have become sensitized to formaldehyde should take precautionary steps to prevent skin contact with liquid detergents, cleaning solvents, deodorizers, concentrated fabric softeners, perfumes, skin creams or other cosmetics, or other materials which may contain formaldehyde and cause a skin reaction. Inhaled formaldehyde gas from other sources such as tobacco smoke, particle board, plywood and treated fabrics may also cause symptoms.

2.2 Formaldehyde Gas (Odour) and its Entry into the Living Space

The odour of formaldehyde gas is one of a number of odours which may be emitted from a cavity containing UFFI. The odour of formaldehyde gas can be described as pungent (sometimes sweet) in high concentrations but less definitive at low concentrations. Other odours can be related to moisture. Fungal growth often produces a musty odour.

The urea-formaldehyde-based resin used in producing the foam contains free formaldehyde which is said, by the manufacturers, to be necessary for the reaction between the resin and the foaming agent. Much of this free formaldehyde gas is released from the foam shortly after installation. Formaldehyde gas is also liberated from the UFFI when the reaction between the resin and foaming agent is reversed causing degradation of the UFFI. The rate of degradation increases with increased humidity and/or increased temperature. The gas that is emitted may be carried away immediately by air movement or it can be stored in the foam or other materials in the wall and then enter the house by air movement or diffusion through the wall. This degradation also decreases the effective thermal resistance of the UFFI.

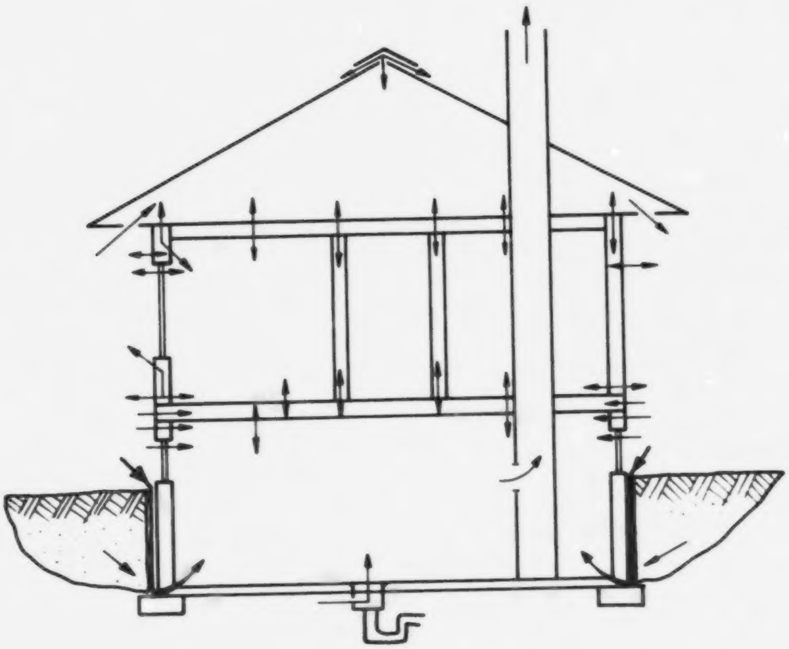

FIGURE 1

POTENTIAL AIR LEAKAGE PATHS IN A WOOD-FRAME HOUSE

Air movement is a more efficient mechanism than diffusion for transporting the gas. Figure 1 identifies some of the common air leakage paths encountered in wood-frame houses. The rate of air flow is governed by the details of the house construction and the pressure difference across the wall cavity. The latter depends on the way the house is operated, the difference between the temperature and humidity inside and out, time of day, wind speed and direction, location of openings relative to wind direction, and furnace operation. Air may flow from the outside into the cavity, then into the living space carrying the formaldehyde gas with it. The air flow may also be in the reverse direction carrying the formaldehyde gas to the outside. Further discussion of the principles of air infiltration is contained in Section 3.1.

In two apparently similar houses having the same brand and batch of UFFI, installed by the same applicator, the resultant material may differ so much that one house could have a problem and the other not. Even where the rate of formaldehyde gas emission from the UFFI in both houses is the same, the gas can be carried to the outside in one case and to the inside in the other case due to the characteristics of the houses and their operation.

Formaldehyde gas can collect in areas of a house where there is restricted air movement, such as under skirted sofas, and so may be difficult to remove by occasional venting of the house. Formaldehyde gas can be entrained in a moist air flow and collect near the ceiling. Formaldehyde can be absorbed by wood and adsorbed on linens, draperies, carpets, and surfaces of walls and furniture.

Since the smell of formaldehyde in contaminated air will seem strongest when compared to cleaner air, its presence is usually easiest to detect when a person enters the house from outside. If detectable, the odour will be strongest where gas is entering the house from an insulated cavity. Openings around electrical boxes in exterior walls are common entry points. The presence of formaldehyde gas in the wall can be sensed by checking for odours around these boxes. A small hole drilled into the wall cavity, just above the floor in the first storey wall where air infiltration is expected, may also be used to check for odour.

2.3 Moisture in the Insulated Cavity

The presence of moisture in an insulated cavity is undesirable for two reasons. First, moisture increases the rate of formaldehyde emission over that which would occur under dry conditions. Second, if sufficient moisture is present, fungal growth may occur either on the foam or the surfaces of the cavity. Spores from the fungus can be transported, in the same manner as formaldehyde gas, by the air that flows from the wall cavity into the living space. Fungal growth may also penetrate through the gypsum or lath and plaster and appear as a growth or discoloration on the painted surface. The growth of wood rot and other fungi can have a serious effect on the long-term integrity of the wood structure as well as being a potential health risk to the occupants.

Moisture in an insulated cavity may come from a number of sources. Just after being installed, UFFI contains up to 75 per cent water by weight. The foam must be able to dry quickly and remain dry. Under some adverse conditions the UFFI and cavity may stay wet for several months or even years after installation.

Moisture may also enter the wall as a result of rain leakage and of condensation of moisture from humid air leaking from the living space into the insulated cavities during cold weather. Both of these sources can cause either general or localized moisture build-up.

The measurement of the moisture content of wood components is one of the tests required in the investigation. The moisture content can be determined using a moisture meter as described in Appendix B. Measurements made at test openings or at intervals along the bottom plate (or lower portion of the stud) in the wall will provide an indication of general and localized moisture levels and the potential for fungal growth.

The moisture content of wood in most cases must remain over 20 per cent for more than 3 weeks to establish the growth of wood rot varieties of fungus. Other less common types of fungi may grow at lower moisture levels.

The presence of fungal growth in the foam and cavity may be observed by cutting a test opening through the interior wall finish (Appendix B). Another way to observe the condition of the material in the wall cavity is by using an optical probe (endoscope) (Appendix B). The most appropriate location is where the moisture content of the bottom plate of the wall has been measured and found to be high or where there are obvious signs of fungal growth such as a growth on, or discoloration of, the surface. When observations indicate possible fungal growth, a test opening should be cut to remove material samples for analysis. Samples of the foam and surrounding organic material should be submitted for identification as described in Appendix B.

The action steps for dealing with walls having a high moisture content are outlined in Appendix A, Table A-1. Possible methods for drying the walls are discussed in Appendix B.

If fungal growth is suspected or has been identified, a consulting engineer or architect knowledgeable in the control of fungus should be retained to investigate the problem and advise on remedial measures.

2.4 Visible Indications of a Problem

Cases of exceptionally poor application can often be identified visually. If, at the time of UFFI application, there is leakage of the resin component (usually a light brown liquid) - this indicates one or more problems. These include an incorrect ratio of the components, application of the material in unsuitable weather conditions, incompatibility of the UFFI with the other building materials, or the component chemicals (resin) used were beyond their shelf life. This information is useful in selecting measurement locations or assessing the extent and nature of remedial measures.

Paint peeling or flaking on the siding or interior finish may indicate that the cavity did not dry properly. The corrosion of electrical boxes or terminals in insulated cavities also indicates that moisture is or was present. Some electrical boxes may have been filled with UFFI during application and not subsequently cleaned. This can encourage corrosion and overheating of the terminal. An electrician should check the receptacles and replace any that have been damaged.

Fungi blooming on the wall surface may indicate fungal growth in the cavity. When fungal growth is suspected, the procedures in Section 2.3 should be followed.

2.5 UFFI Locations Requiring Special Consideration

The use of UFFI in locations other than empty exterior wood-frame walls, such as masonry walls, attics, ceilings and below-grade locations, has been discouraged by various authorities. The inability of the cavity to dry through to the exterior, the risk of moisture entering the cavity from rain or groundwater leakage, and higher temperatures in attics and ceilings, all contribute to the need to limit the use of UFFI. The Canadian General Standards Board Standard for UFFI indicated its application only in exterior wall cavities. Canada Mortgage and Housing Corporation in 1977 accepted UFFI only for use in empty exterior wood-frame wall cavities.

Special attention should be given where UFFI has been installed in the locations discussed below.

Cathedral ceilings, flat roofs and attics

UFFI installed in cathedral ceilings (Figure 2), flat roofs, and attics is exposed, often simultaneously, to high temperatures and high humidities. The foam may also be subjected to moisture from roof leaks and to accumulation of condensation due to leakage of moist air and diffusion of water vapour through the interior surface in winter. Under these conditions, generation and concentration of the formaldehyde gas in the cavity will increase. Air flowing downward through the ceiling

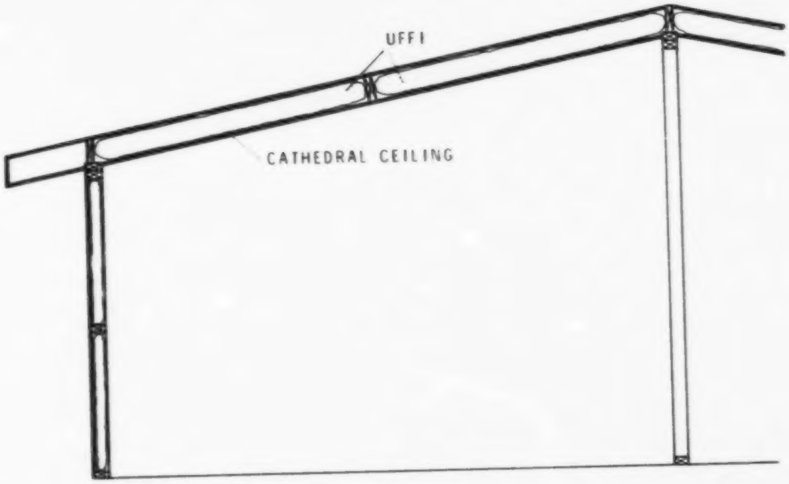

FIGURE 2

UFFI INSTALLED IN CATHEDRAL CEILING

during the operation of a fireplace, furnace, stove and/or bathroom fan, and when particular wind conditions exist, carries the formaldehyde laden air into the living space.

UFFI installed in the floor of open attics is subjected to air movement over its surface. This may result in an increase in the emission of formaldehyde due to a change in the equilibrium of free formaldehyde in the foam. The foam will liberate more formaldehyde in an attempt to re-establish equilibrium. Cracks in the UFFI can increase the rate of liberation as they allow rapid loss of formaldehyde gas.

Overhangs, canopies and intermediate floors

UFFI has been installed in overhangs (Figure 3), canopies and intermediate floors. With balloon frame construction this may have happened accidentally where the wall cavity is connected to open joist spaces (Figure 4). In other cases, these areas were insulated in an attempt to reduce air infiltration and eliminate cold floors. Construction details often provide numerous openings and cracks which allow air and formaldehyde gas infiltration into the living space.

Below-grade applications

UFFI was considered unsuitable for installation below grade (Figure 5), because of the prolonged exposure to high humidity, water leakage, and the absence of a good drying environment. If these conditions exist the rate of degradation of the foam would be high and result in a higher rate of formaldehyde emissions. Air movement at this level is normally from the outside through the insulated cavity to the living space. Almost all the formaldehyde released from the UFFI would, therefore, enter the house.

Interior partitions

UFFI has been used in a limited number of cases as an acoustical insulation in party walls or partitions. In such locations, the UFFI is exposed continuously to room conditions. As a result, the foam tends to be warmer than if it was in an exterior wall. Since there is little, if any, air flow to the outside and most interior partitions do not have a good air seal at the floor/wall junction, the formaldehyde gas is more likely to enter the living space.

2.6 Measurement of Formaldehyde Gas

Knowledge of the formaldehyde gas concentration in the insulated cavity, and in some situations the living space, is essential to the analysis of a UFFI problem or in determining the potential for formaldehyde gas infiltration. If the UFFI must be removed, the

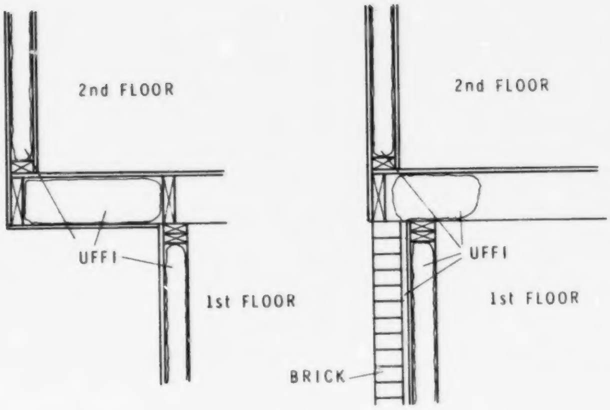
2nd FLOOR
UFFI
1st FLOOR
2nd FLOOR
UFFI
1st FLOOR
BRICK

FIGURE 3
UFFI IN FLOOR OVERHANGS

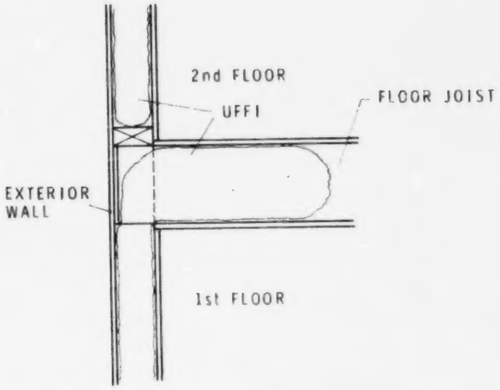
2nd FLOOR
UFFI
FLOOR JOIST
EXTERIOR WALL
1st FLOOR

FIGURE 4
UFFI IN JOIST SPACES IN BALLOON-FRAME CONSTRUCTION

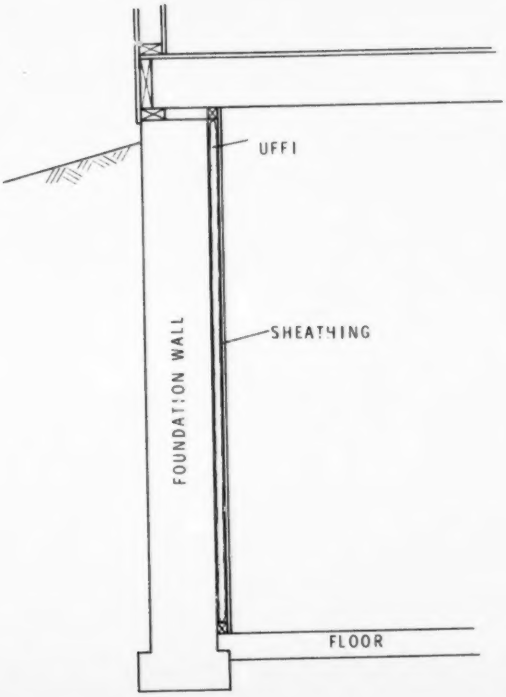
UFFI
SHEATHING
FOUNDATION WALL
FLOOR

FIGURE 5
UFFI IN BASEMENT WALL

measurement of the rate at which material in contact with the UFFI emits formaldehyde is one factor to be considered in establishing the removal procedure. This test is conducted under laboratory conditions.

Insulated Cavity Gas Concentration

The potential for high formaldehyde gas concentrations in the living space is best defined by measurements of the formaldehyde gas concentration in the insulated cavity. This type of measurement can be done by consultants or the homeowner. Compared with the air in the living space, the air in the insulated cavity will generally have a higher concentration of formaldehyde gas and be influenced less by external factors. If the concentrations of formaldehyde in the insulated cavities are high, then air leaking through the cavity into the living space will have a high formaldehyde gas concentration. The concentration of formaldehyde gas in the wall cavity has therefore been selected as one of the measurements on which to base a decision on the extent of remedial measures required for a particular house.

Gas Concentration in the Living Space

Measurements of formaldehyde gas in the living space should only be done after the necessary preparatory steps have been carried out. These steps are described in detail in Appendix B. Because of the complexity of the equipment and analysis, the measurement is conducted by consultant or laboratory personnel.

The concentration of formaldehyde gas will be affected by many factors including changes in wind speed and direction, temperature, humidity and house operation. The measurement of formaldehyde gas in only the living space therefore, is generally not sufficient to establish a course of remedial action. It is useful, however, to carry out measurements of the concentration in the living space in addition to those in the wall cavities when there is a need to determine the effectiveness of the remedial measures or where there have been related health problems. The initial ratio of the formaldehyde gas concentration in the living space to the concentration in the insulated cavity is a benchmark which can be compared with measurements made after completion of remedial measures. If the UFFI has been removed, the measurement of the formaldehyde gas concentration in the living space should be compared with the ambient concentration. Ambient concentrations will vary within a city and will generally range from below 0.01 to 0.03 ppm (parts per million). Higher ambient concentrations will exist in areas of heavy traffic.(3)

Formaldehyde Emission from Materials in Contact with UFFI

A laboratory test procedure* for measuring, under a standard set of conditions, the emission of formaldehyde from cured UFFI was developed by Rybicky and Kambanis of Reichhold Chemicals.(4)

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*The procedure was reviewed by the Canadian General Standards Board Committee for UFFI and proposed for inclusion in the standard. Laboratories can obtain copies of the Reichhold procedure by writing to Standards Office, Canadian General Standards Board, Department of Supply and Services, Ottawa, Canada, K1A 1G6.

The test can be performed by material testing laboratories. The apparatus used in the test can also be used to assess the potential for formaldehyde emission from other materials such as gypsum board, lath and plaster, and fibre board.

Such testing of materials in contact with UFFI is necessary when the UFFI is going to be removed. The results identify the extent to which resin-laden water from the UFFI was absorbed by other materials. This is an important factor when the foam was not properly installed and resin-laden water was released. When in contact with water or high-humidity air, the resin-soaked materials could become a significant source of formaldehyde gas. In some cases when UFFI must be removed from the cavities, and where the gypsum board or lath and plaster has been shown to have a high formaldehyde gas generation capability, the foam should be removed from the interior and the gypsum board or lath and plaster replaced.

2.7 Summary - Problem Identification

The preceding provides information necessary to investigate a problem related to UFFI. The completed investigation should yield the following information:

1) The nature of the problem
    - health
    - odour
    - moisture
    - not identifiable
2) Moisture content of wood in cavity
3) Formaldehyde gas concentration in the insulated cavity and possibly the living space
4) Which cavities were insulated with UFFI.

With this information a decision must be made regarding the remedial measures to be taken to reduce the severity or cause of the problem. There are a number of options available; these are discussed in terms of Action Steps and Remedial Measures in Appendix A. These steps are categorized by the type of problem and broken down into "classes" based on the test results. The classes are determined using the relationship between formaldehyde gas concentration in the wall cavities, temperature, and relative humidity (Figure A-1). The action steps represent the minimum remedial measures that should be considered and should not be regarded as the only way to approach a problem relating to UFFI insulation.

An understanding of the options is required before decisions can be made regarding the remedial measures. These remedial measures are discussed in Section 3.

3.0 REMEDIAL MEASURES

Procedures for reducing formaldehyde gas concentrations in homes have only recently been established and their application to a wide variety of houses is limited. The properties of the UFFI in a particular house, the sensitivity of the occupants, and the building characteristics will all affect either the type and severity of, or potential for, problems. No two houses, occupants or UFFI installations are likely to be the same and thus the success of remedial measures will vary. Only guidelines to the selection of the appropriate remedial measures can be provided. The interpretation of the guidelines by a consulting engineer or architect may be required.

3.1 Principles of Remedial Measures

Air Infiltration

Air infiltrates through openings in a house when and where the outside air pressure is higher than the interior air pressure. (This is called negative pressure difference.) It is impossible to eliminate all air infiltration even when a conscious effort is made to seal holes in exterior walls. The effects of wind, temperature, chimneys and, in winter, stack action* on the pressure across a wall are illustrated in Figure 6. As shown, one section of the exterior wall can be under a positive pressure difference and another section can be under a negative pressure difference at the same instant. Positive pressure differences (interior air pressure higher than that outside) cause air to flow from inside to the outside carrying formaldehyde gas, and fungus spores if present, into the atmosphere. Negative pressure differences result in an inward flow of air. The negative pressure differences should be reduced to minimize infiltration of formaldehyde laden air.

Air pressure differences in the living space, however, should not be increased to the point where there is excessive flow of moist indoor air into the wall as this could cause serious condensation problems in cold weather. If a house is pressurized to reduce the negative pressure difference, the humidity level in the living space should be kept as low as possible without causing discomfort to the occupants. This will further reduce the possibility of damage caused by condensation in the cavity. As many openings as possible through which air can leak into the wall or roof space should be sealed to reduce the possibility of condensation accumulation.

Formaldehyde Gas Concentration

UFFI and materials that have come in contact with the wet foam release formaldehyde gas. Any flow of air from the insulated cavities to the living space will carry the formaldehyde gas increasing the concentration in the living space. There is also a small indeterminate amount of formaldehyde gas that diffuses from the insulated cavity through the wall materials to the living space. The lath, plaster,

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*pressure differences caused by the warm moist air expanding and rising.

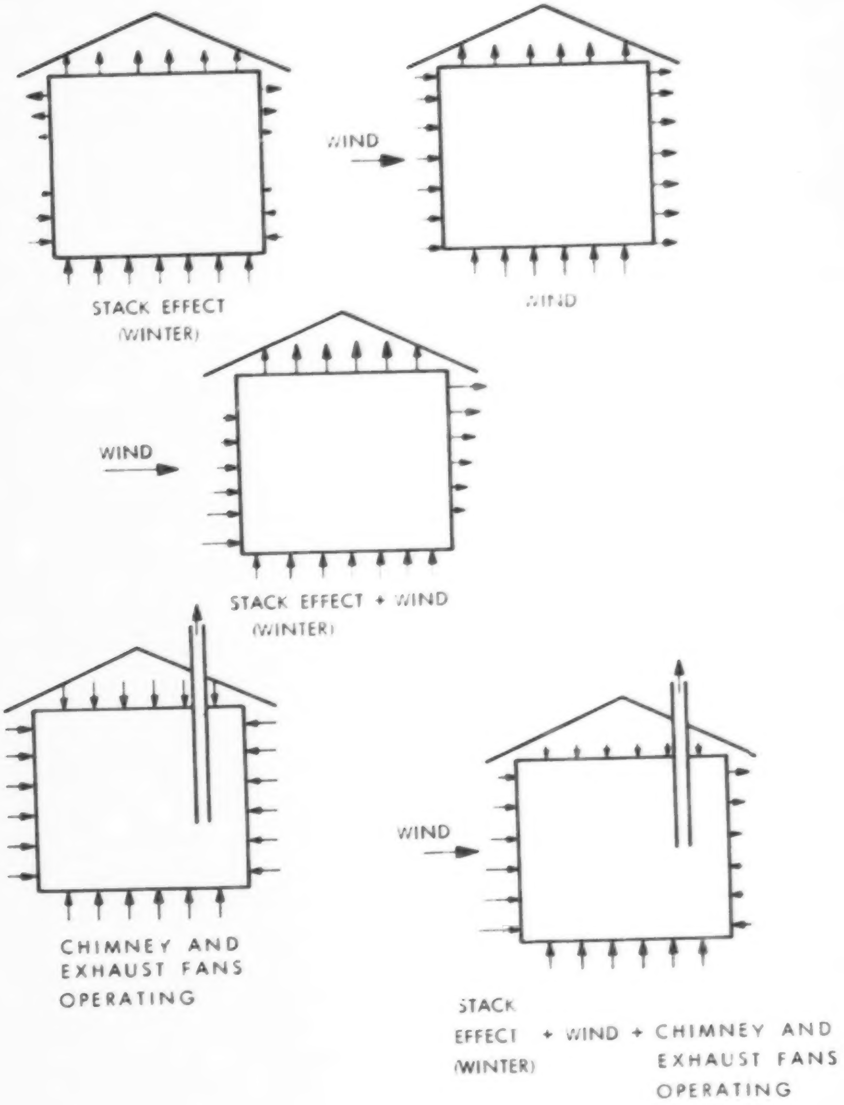

STACK EFFECT
(WINTER)
WIND
WIND
WIND
STACK EFFECT + WIND
(WINTER)
CHIMNEY AND
EXHAUST FANS
OPERATING
WIND
STACK
EFFECT + WIND + CHIMNEY AND
(WINTER) EXHAUST FANS
OPERATING

FIGURE 6
SIMPLIFIED PRESSURE DIAGRAMS FOR HOUSES

gypsum board or sheathing that is between the insulated cavity and the living space have pin holes, cracks and joints that are open to the air space so they can only provide a limited resistance to air flow. The concentration of formaldehyde gas in the living space is also affected by the concentration of formaldehyde in the outside air, the rate of emission of formaldehyde from indoor furniture or furnishings, and other activities that produce formaldehyde such as frying and smoking.

The concentration of formaldehyde in the air in a house can be estimated using simplified equations from a knowledge of the formaldehyde gas concentration in the insulated cavity and an estimate of the air leakage characteristics. Consider the effect of the concentration of formaldehyde gas in the outside air. If it is constant at all times of the day and if there are no other sources of formaldehyde, the concentration of formaldehyde gas in the living space air would rise to that of the outside. In actual conditions, the contributions from outside would be a constant that is added to all the other contributing factors.

For simplicity, then, it is possible to limit the discussion to the contribution made by the UFFI to the living space concentration of formaldehyde gas.

On average, the amount of air that flows into a room must equal the amount that flows out (Figure 7). Let n equal the amount of air that flows into a room through cavities containing UFFI and m equal the amount of air flowing into the room through other openings. The rate at which air must leave the room is therefore $m + n$.

Assume that the average concentration of formaldehyde gas in the insulated cavities is C_c and that from all other sources is zero. Then the amount of formaldehyde gas entering the living space per unit of time is $n \times C_c$. Let the concentration of formaldehyde gas in the living space be defined as C; the amount of formaldehyde leaving the living space is then $(m + n) \times C$. When the concentration of formaldehyde gas in the cavity and the air flows are constant,

$$n \times C_c = (m + n) \times C$$

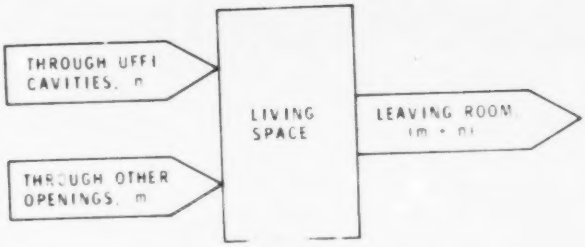
or

$$C = (n/(m + n))\ C_c$$

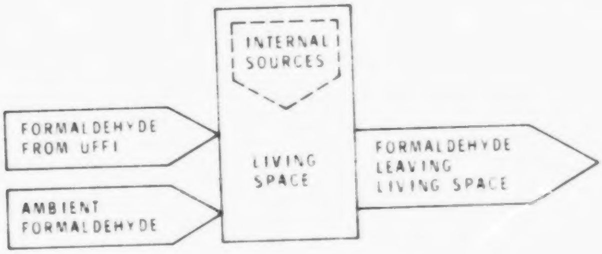
The amount of air flowing through the insulated cavity, n, is usually much smaller than that from all other sources so that approximately,

$$C = (n/m) \times C_c$$

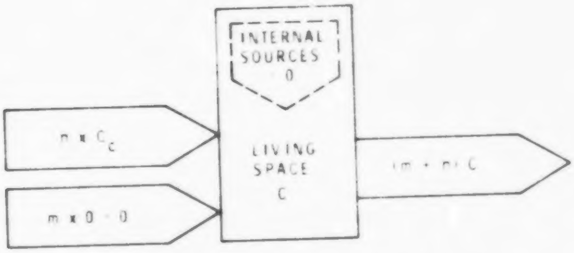
That is, the concentration of the formaldehyde gas in the living space is reduced from that in the cavity by the ratio of the rate of flow of air through the cavity to the rate of flow of air from all other sources.


THROUGH UFFI
CAVITIES, n
THROUGH OTHER
OPENINGS, m
LIVING
SPACE
LEAVING ROOM,
(m + n)

AIR FLOW IN   AIR FLOW OUT


INTERNAL
SOURCES
FORMALDEHYDE
FROM UFFI
AMBIENT
FORMALDEHYDE
LIVING
SPACE
FORMALDEHYDE
LEAVING
LIVING SPACE

FORMALDEHYDE SOURCES


INTERNAL
SOURCES
0
n x C_c
m x 0 = 0
LIVING
SPACE
C
(m + n) C

AIR FLOW AND FORMALDEHYDE BALANCE

FIGURE 7
FLOWS OF FORMALDEHYDE GAS THROUGH A LIVING SPACE

Based on limited NRC data, the following are the approximations for n/m:

- for air flowing inward through the walls of modern houses that have gypsum board finish with foam only in the walls, n/m is 1/15 to 1/20

- for houses built with lath and plaster, n/m is 1/25 to 1/35

The units of measurement for formaldehyde gas are commonly parts per million (ppm) or milligrams per cubic metre (mg/m^3). The unit parts per million will be used in the discussions since this is the unit read by the instruments for measuring wall cavity concentrations. The relationship (5) between those units is, 1 ppm = 1.248 mg/m^3.

Example

If n/m = 1/15, there are no other sources of formaldehyde gas, and the formaldehyde gas concentration in the wall cavity is 1.5 ppm. Then the contribution to the living space concentration of formaldehyde gas by the UFFI foam would be

$$1/15 \times 1.5 = 0.1 \text{ ppm}$$

The foregoing simplified method can be used to identify measures to reduce the concentration of formaldehyde gas in the living space. These measures are:

1) increase m, the flow of outside air directly into the house. If m was doubled, C would be reduced by one half. This could be accomplished by selective window openings or by blowing outside air into the living space with a fan.

2) decrease C_c, the concentration of formaldehyde gas in the insulated cavity. If C_c was reduced by half, C would also be similarly reduced. This could be accomplished, for example, if the UFFI was wet and the cavity was subsequently dried.

3) decrease n, the flow of air through the insulated cavity. If n was reduced by half, C would be also. This could be accomplished by sealing the openings from the cavity to the inside and by decreasing the negative pressure difference across the wall, which is the force causing the air infiltration.

4) the overall concentration in the living space can be reduced by circulating the air in the living space through special filters.

It should be remembered that we have assumed outside formaldehyde gas concentrations and formaldehyde gas from other indoor sources to be zero. The contribution from outside could only be reduced by using special filters. The indoor sources can be reduced by either ventilation or special filters.

Although the remedial measures discussed in the following generally apply to UFFI installed in wood stud walls, they can, with some care, be applied to UFFI installed in other locations such as flat roofs, cathedral ceilings and to masonry construction. Each situation will, however, have its own peculiarities which must be considered.

Remedial measures aimed at reducing the amount of formaldehyde gas entering the living space are most effective when combined. Sealing reduces the formaldehyde concentration in the living space and slightly reduces the air change rate while other measures will increase the air change rate. Figure 8 is a graphical illustration of the accumulated effects of sealing the exterior wall, and ventilation and pressurization of the living space. Although simple ventilation dilutes the formaldehyde gas, it is often not adequate to bring the concentrations down to near-ambient concentrations without excessively high air change rates. A combination of sealing and pressurizing to reduce the negative pressure difference may be the most effective method of reducing the concentration of formaldehyde gas in the living space. The type of

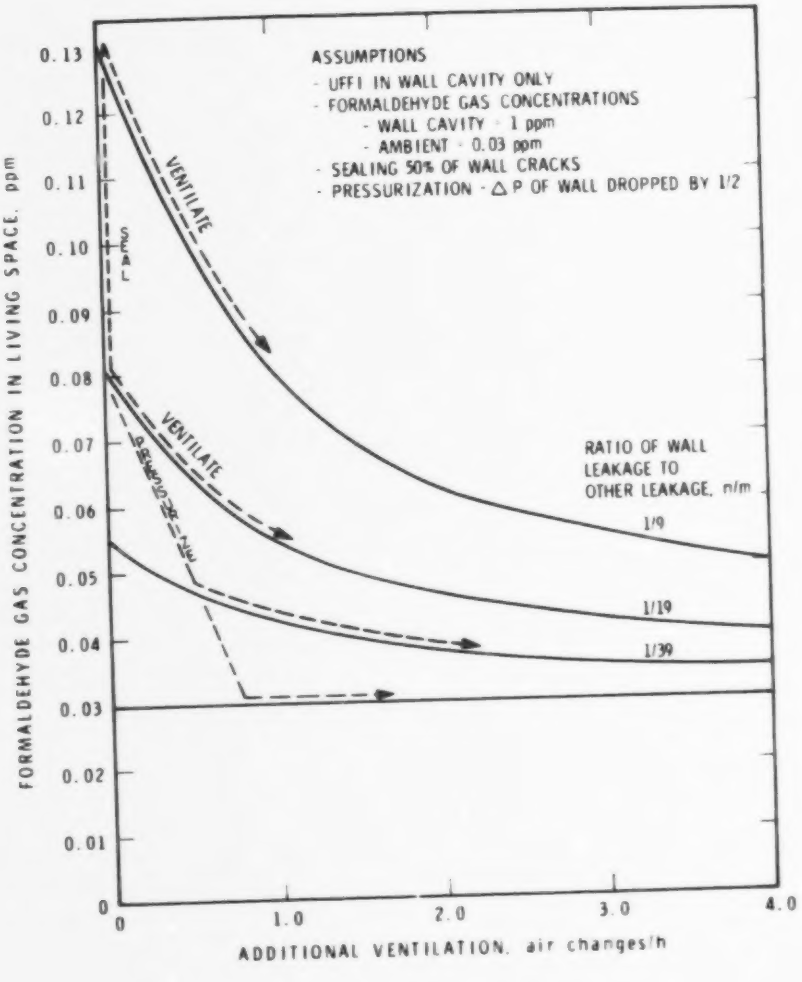


FIGURE 8

ACCUMULATED EFFECTS OF REMEDIAL MEASURES ON FORMALDEHYDE GAS CONCENTRATION IN LIVING SPACE construction will have a bearing on which remedial measure is emphasized. For example, balloon frame construction is very difficult to seal adequately because of the floor-joist wall-stud junction. One would seal those areas which would be effective but put more emphasis on the forced ventilation measure to reduce the air infiltration.

The development of new or more effective techniques may be required to meet the unique characteristics of a particular house or construction type. Appendix D provides a summary of the basic types of Canadian house construction.

Interim Measures

In cases where occupants of a house are particularly susceptible to the presence of UFFI, some of the less expensive remedial measures may be necessary as interim measures until a proper long-term course of action is decided upon. Taping of baseboards, fans and increased air change rates are effective means of temporarily reducing formaldehyde concentrations. The contribution to the formaldehyde gas concentration in the living space from other internal sources will also be reduced by additional air changes.

3.2 Sealing the Inside Surface of the Exterior Walls

Regardless of other remedial measures taken, the gypsum board or lath and plaster on the exterior wall should be sealed to prevent infiltration of formaldehyde-laden air. All holes, cracks or gaps in the wall finish must be repaired.* In cases where the UFFI is to be removed, sealing of inside surfaces is still necessary to reduce the possibility of residual formaldehyde gas entering the living space. It may, however, be done after the UFFI is removed, depending on the procedure used.

Electrical Outlets

Electrical outlets are a common source of air leakage and should be sealed by applying a gasket between the cover plate and the wall. Inexpensive gaskets are available at hardware or building supply stores. Gaskets that are CSA approved and acceptable to the local electrical authority should be used. The local electrical authority should be contacted to determine if regulations require that the gaskets be installed by an electrician.

Wall/floor junction

The junction between the interior wall finish and the floor should be sealed against air infiltration. Acoustical sealant is commonly used for this purpose (Figure 9). Other techniques to produce a seal can also be effective. The use of weatherstripping or special foam-backed tapes available at hardware stores is illustrated in Figures 10 and 11.

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* mylar, foil, or vinyl wallpaper provides an air leakage and diffusion barrier.

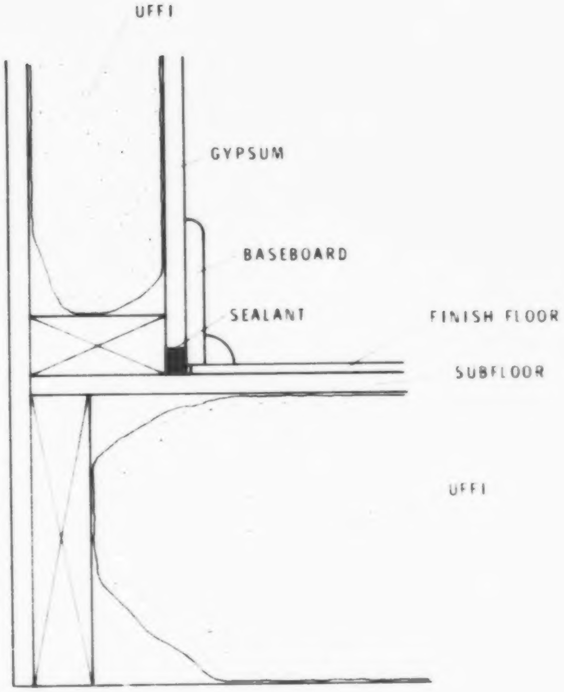
UFFI
GYPSUM
BASEBOARD
SEALANT
FINISH FLOOR
SUBFLOOR
UFFI

FIGURE 9
SEALING WALL/FLOOR JUNCTION WITH SEALANT

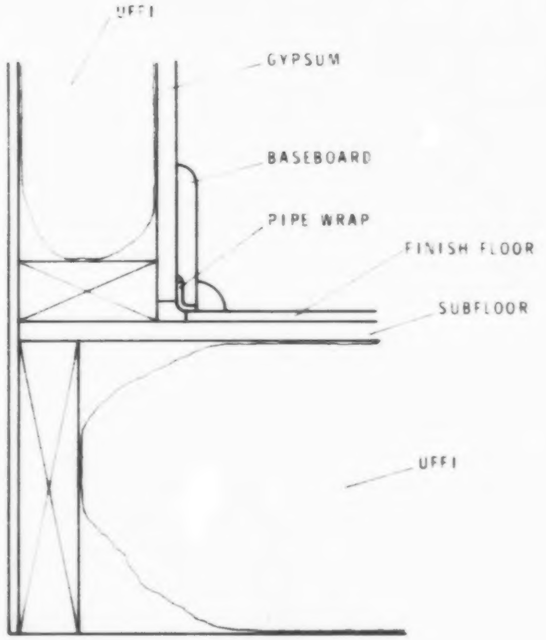
UFFI
GYPSUM
BASEBOARD
PIPE WRAP
FINISH FLOOR
SUBFLOOR
UFFI

FIGURE 10
SEALING WALL/FLOOR JUNCTION WITH PIPE WRAP

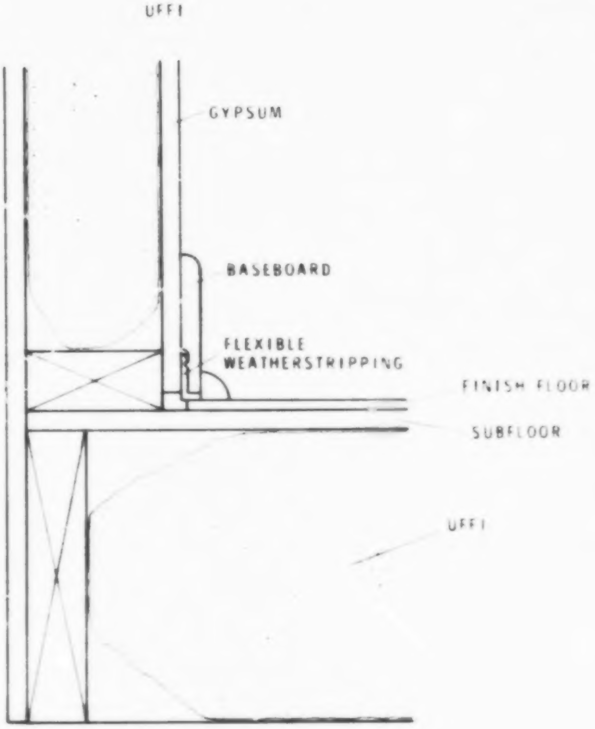
UFFI
GYPSUM
BASEBOARD
FLEXIBLE WEATHERSTRIPPING
FINISH FLOOR
SUBFLOOR
UFFI

FIGURE 11
SEALING WALL/FLOOR JUNCTION WITH FLEXIBLE WEATHERSTRIPPING

In cases where board subfloor was used, sealing between the boards will be required to reduce movement of air into the floor space and back into the living space at some other location. If odours from sealants cause discomfort to, or a reaction in, occupants sensitive to the formaldehyde gas, the sealants should be covered by aluminum tape or another technique that produces less odour should be used. Some imagination combined with a trip to the local hardware store may result in a neat, effective method to seal a particular wall to the floor. The joints around window and door frames should be sealed where there are openings between the rough opening and the frame. In two-storey houses, air leakage paths connect the wall cavities to the space between the first and second floor. Such paths may require special consideration. The flooring and/or gypsum board ceiling may have to be removed to gain access to these locations. This may be impractical. Infiltration is therefore best reduced by reducing the negative pressure difference across the wall as discussed in Sections 3.3 and 3.4.

Wall surfaces

Wall surfaces must be sound, free of pin holes and cracks, and covered with good quality paint or wall paper to prevent air leakage and reduce the diffusion of formaldehyde gas through the material. If the gypsum board or lath and plaster has been cracked due to the pressures developed during installation of UFFI, these cracks should be repaired before repainting or wall papering. If a bulge that is cosmetically undesirable has been produced by the UFFI installation, the interior wall finish should be removed. The UFFI can then be removed following the procedures described in Section 3.6.

Where UFFI was installed in a wall finished with paneling and where the wall does not have a polyethylene air/vapour barrier or the joints between panels are not sealed, the joints should be sealed. This type of paneling can often be readily removed and reapplied, facilitating the removal of the UFFI. Paneling suspected of being an additional source of formaldehyde gas should be checked for emissions before reinstallation.

Interior Partitions

Until very recently, there was no attempt during house construction to provide an air barrier at the junction of interior partition walls and exterior walls. Cold drafts at the floor line or from the electrical outlets in the partition wall are good indicators of paths of air infiltration. These locations should be sealed especially where the formaldehyde gas concentrations in walls are high. Negative pressure differences that encourage infiltration should be decreased as described in Sections 3.3 and 3.4.

3.3 Increasing Ventilation by Use of Forced Air Furnace Fan or Windows

One simple way to reduce the negative pressure difference across a wall is to install a fresh air intake on the cold air return duct of a forced air furnace (Figure 12). A furnace maintenance company should be contacted regarding installation. The intake must draw air from the windward (prevailing wind) side of the house. The furnace circulation fan, preferably two speed, should be set to run continuously at low speed. This will provide a controlled rate of air supply and a reasonable distribution. The duct should be approximately 100 mm to 150 mm in diameter, contain a one-way damper and be insulated to minimize condensation on the pipe. If the pressure in the house is excessive, the damper should be adjusted to reduce the inward flow of air. The furnace fan speed could also be slightly lowered to reduce noise when the fan motor operates at a single speed. This adjustment should be made by a furnace service person who should also check the operating temperature of the furnace. The pressure difference across the wall at the first floor level can be checked with special sensitive differential pressure indicators.

Operation of kitchen or bathroom fans, clothes dryer, or other exhaust-type fan will probably increase the rate of infiltration by increasing the negative pressure difference across the wall. Operation of these exhaust fans should be reduced to a minimum or modifications made to the system.

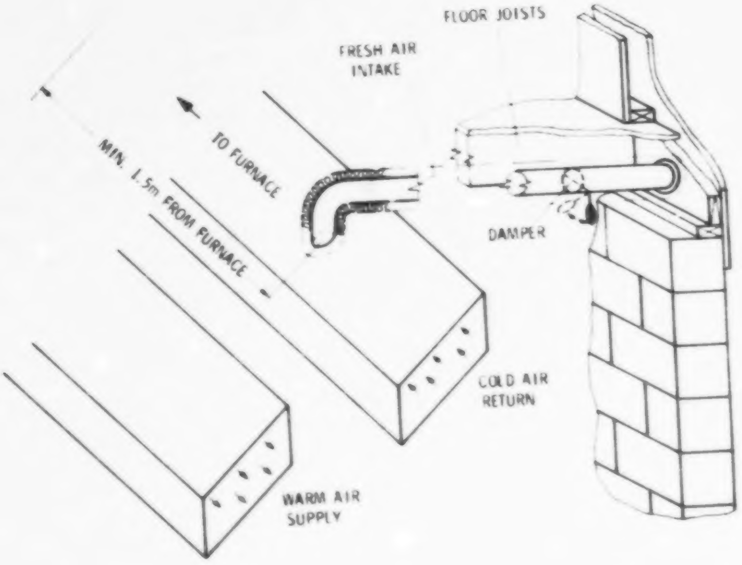

FIGURE 12
FRESH AIR INTAKE

Window ventilation may be effective for removing formaldehyde from the living space when the windows can be left open for extended periods of time. The flow of fresh air from windows, however, is not well controlled. In winter, since cold drafts will result, it is most likely that the windows would be closed before adequate ventilation is achieved. If windows are being used for ventilation they should be opened so that there is greater open area on the windward side(s) of the house than the sum of openings on the leeward and other sides. The amount of negative pressure difference that usually exists across the main floor walls will be decreased if a basement window, on the windward side of the house, is left open. The wind in this case would act like a fan blowing into the basement. Problems with drafts, pooling of cold air, lack of security and the possibility of rodent entry may have to be considered if windows are used as a source of ventilation or to reduce negative pressure differences.

Fireplaces should be sealed when not in use to reduce the depressurization of the house caused by air flow up the chimney. Most fireplace dampers do not provide such a seal. A sheet of plywood cut large enough to cover the opening can be edged with suitable weatherstripping and anchored to the adjoining wall or masonry. Installation of a dampered duct from outside the house to the vicinity of the fireplace grate will act as a combustion air intake and will reduce the depressurization otherwise caused by the flow of air from the living space up the chimney. This can also be accomplished by opening a window a small amount during operation of the fireplace.

3.4 Forced Ventilation

Houses do not always have a forced air heating system and the ventilation provided by a fresh air intake on the furnace is not always adequate. In these cases, a separate forced air ventilation system should be installed. The forced air ventilation system utilizes a fan to supply outdoor air to the living space. This fan may be installed in conjunction with an air to air heat exchanger as described below. The addition of the heat exchanger allows increases in the air change rate well above that which could be provided by one fan or which would be economical using two fans.

A ventilation system will reduce the negative pressure difference across the exterior wall and will decrease the air infiltration. Flows should be adjusted so that the pressure difference is close to zero at the ground floor level when the furnace is not running. The fresh air supply from the fan or heat exchanger should be connected to a distribution system; to the forced air heating system when there is one. A small distribution system using small ducts should otherwise be considered.

Fans

Forced ventilation can be provided with a good quality centrifugal or squirrel cage fan that operates with a low noise level. The fan can be installed in a basement window so as to draw air from outside and discharge it into the basement. An electric heater can be installed after the fan's discharge to reduce cold drafts and reduce the possibility of pipes freezing. The cost of the fan system should be less than $500, but for houses that cannot be adequately sealed the cost to heat the air would be high. When fan inlets are located in areas accessible to children, protective covers should be installed to prevent accidents.

Heat Exchangers

Heat exchangers have become common in low energy houses where the air leakage has been reduced to the point that a supply of fresh air is required to maintain air quality. Heat exchangers can be obtained with a pair of adjustable speed fans, one on the intake and the other on the discharge. These fans force air through the heat exchanger in opposite directions. Heat is transferred from the room air through a conductive membrane to the cold fresh air flowing in the opposite direction. The efficiency of heat recovery is highest where the two flow rates are equal but this will occur only in very tight houses or in very special circumstances.

When a heat exchanger is installed in houses containing UFFI, the volume of supply air should be greater than that of the exhaust air to reduce the negative pressure differences across the exterior walls. The conductive membrane in the heat exchanger must operate with a pressure difference across it. The manufacturers should be consulted prior to purchase to confirm the suitability of their product to this type of application. The prices for heat exchangers in 1981 run from approximately $400 to $1000. Less expensive portable models are now available for individual room ventilation.

3.5 Air Filter System

Filtering systems are available which remove formaldehyde gas from air. The formaldehyde-laden air is circulated through a series of filters, one of which is a granular chemisorbent bed. The formaldehyde gas is first adsorbed by the chemisorbent granules. A chemical then reacts with the adsorbed gas in an irreversible chemical reaction. The filter system also removes from the air a number of other pollutants and other components of UFFI gas to which a person already sensitized by the formaldehyde gas might react. The filter medium has a limited life because the chemical is depleted as it reacts with the pollutants. Carbon monoxide and carbon dioxide are not removed from the air so must be exhausted to the outside, necessitating a supply of fresh air to the living space.

The filter system can be installed in a permanent position or mounted on casters and moved about the house as required. The output from the filter can be ducted to an air distribution system to ensure that filtered air reaches all parts of the house. Doors between rooms should be left open to allow the air to circulate. The distribution of the filtered air can be assisted by using portable circulating fans when the unit is located on the main floor and not connected to a distribution system or when a portable unit is used.

Filter systems range in price (in 1981) from $1000 to over $3000. The size of unit required depends on the sensitivity of the occupants, the concentration of pollutants and the size of house. The house should be sealed as discussed in Section 3.2 to reduce infiltration of formaldehyde-laden air which would decrease the life of the filter medium. The manufacturer of the filter should advise the potential purchaser what byproducts will be emitted from the filter and what particles may be in the air discharged from the filter. In cases of medical problems this information should be passed on to a doctor for comment or to enable tests for sensitivity to the chemicals.

> CAUTION: Persons previously exposed to formaldehyde may be sensitive to small amounts of particulate matter or new products being emitted by the filter. Filter units should be equipped with high efficiency after filters to reduce this possibility. In some cases, an activated carbon filter downstream from the chemisorbent medium is sufficient to reduce to a tolerable level many trace particles or chemicals from the chemisorbent medium. Anyone experiencing a reaction following installation of the filter should immediately discontinue use of the filter and contact a doctor and the manufacturer.

3.6 Removal of UFFI from Wall Cavities

The removal of UFFI from an insulated cavity involves a series of steps which may differ slightly from house to house. The steps will include:

- establishing initial formaldehyde gas concentrations in the cavity and living space
- determining if removal is to be from the inside or outside
- protecting or removing belongings
- opening the cavity surface to gain access to the UFFI
- removing the UFFI
- treating the cavity
- rebuilding the wall to provide thermal insulation, and an effective air seal and vapour barrier
- cleaning the interior of the house
- rechecking the formaldehyde gas concentration in the living space.
- carrying out further remedial measures if required.

Throughout the process, proper protective clothing and equipment must be used by the workers to avoid unnecessary contact with the UFFI. The assistance of an experienced contractor or supervision of a consultant is recommended during the removal of the UFFI.

Although UFFI can sometimes be removed through small holes in one of the wall surfaces, this is not recommended at present because of the difficulty in chemically treating the surfaces of the cavity following removal of the insulation.

Access to the UFFI can be gained either by removing the interior finish or the exterior cladding and sheathing. The choice will depend on the construction of the house, relative costs, time of year, location of the foam, and amount of formaldehyde contained in the gypsum board or lath and plaster.

Removal of UFFI from accessible attics and interior partitions should be considered by the homeowner.

Removal of UFFI, regardless of which side of the cavity is opened, must be accompanied by chemical treatment of any wood and fibreboard remaining in the cavity.

Chemical Treatment Following UFFI Removal

A 3 per cent solution by weight of sodium bisulfite ($NaHSO_3$) should be applied onto the wood in the cavity with a new or very clean fog or airless sprayer, sponge, or mop. The solution is prepared using a ratio of 100 grams of sodium bisulfite in 3.5 litres of water (1 pound in 3.5 imperial (4 U.S.) gallons of water). Spraying should continue in each cavity until slight running of the liquid occurs. This should provide sufficient solution to soak the surface layers of the materials being treated.

If the sodium bisulfite is not available, sodium sulfite can be used in the same concentration. Sodium bisulfite solutions will emit an odour of sulfur dioxide during application and drying. Some people may find the odour unpleasant but with ventilation the actual exposure should be slight (6). Sodium bisulfite is available from chemical supply outlets which are listed in the yellow pages of the telephone book. Local pharmacies may be willing to assist homeowners by ordering the chemicals and preparing the solution. As a safety precaution, it is recommended that the chemical supplier or pharmacy prepare the solution for the homeowner.

WARNING

SOME HOMEOWNERS HAVE MISTAKENLY PURCHASED SODIUM BISULFATE OR SODIUM SULFATE FOR THIS TREATMENT. THESE CHEMICALS ARE MORE HAZARDOUS AND UNSUITABLE FOR THIS USE. OTHER HOMEOWNERS HAVE USED SODIUM META BISULFITE AND LOW IMPURITY COMMERCIAL GRADES OF SODIUM BISULFITE WHICH EMIT GREATER AMOUNTS OF SULFUR DIOXIDE WHEN MIXED WITH WATER. THIS GAS HAS AN UNPLEASANT ODOUR OFTEN REFERRED TO AS A "ROTTEN FISH ODOUR".

PROPER PROTECTIVE EQUIPMENT AS OUTLINED IN SECTION 5.0 IS ESSENTIAL TO THE SAFE HANDLING AND THE USE OF THE CONCENTRATED CHEMICALS AND SOLUTIONS.

Other chemicals for treating the cavity have been tried with limited success. Ammonia gas is difficult to handle and requires several applications. Ammonia solutions are less effective than ammonia gas.

In houses where a serious health problem or sensitization has occurred, the cavity should be dried, covered with a temporary cover such as polyethylene, and left for a minimum of one day or more preferably one week. The formaldehyde gas concentration in the air of the cavity and the living space should then be remeasured. The procedure used for measuring the air in the living space will be required for measuring the concentration in the cavity since the concentration will be below the range of the hand pump detectors. The concentration in the cavity should be near ambient. If the concentration in the living space is still high, a comprehensive investigation should be made to locate UFFI which may have been overlooked or other sources of formaldehyde gas. If the concentration is high in the wall cavities, a second application of sodium bisulfite solution should be made to the cavity, the cavity dried, re-covered and tested again.

The procedure of opening the cavity, removing the UFFI, treating the wood, improving the air barrier, reinsulating and closing the cavity differs depending on whether it is done from the inside or the outside. To emphasize the key points each procedure will be discussed separately.

Removal of UFFI from the interior

There are a number of advantages to removing UFFI from the inside. Often, but not always, fewer layers of material cover the inside surface. The building structure stays protected from the environment. The inside sheathing, which often contains absorbed formaldehyde, is replaced. The exterior sheathing, whether wood or fibreboard, can be treated with the sodium bisulfite solution. An air barrier can be installed over the new insulation on the inside surface of the cavity to provide an improved air seal between the cavity and the living space.

The procedure for removing UFFI from the inside should include the following steps:

- cover or remove all furniture, carpets, draperies and food.

  Removal of UFFI from the interior will create a significant amount of airborne dust and UFFI particles. Unnecessary contamination of household items should be avoided.

- remove all gypsum board or lath and plaster, UFFI and any other material in the cavity such as batt insulation.

  This material should be discarded and not reused. Scrap material can be placed in large rubbish containers of the type used by contractors. These containers are dropped off by the rental company and picked up when full or when the job is finished. A cover for the container is required to prevent the UFFI from blowing out during windy weather.

- check floor spaces, ceilings, and interior partitions

  Ensure that all UFFI is removed. The UFFI may have been put in these locations accidentally because of the way in which the house was built.

- brush, vacuum and inspect the cavity

  The cavity surfaces should be brushed and vacuumed to remove all residual foam. The wood should be checked for evidence of fungal growth. If fungus is present a consulting engineer or architect should be retained as discussed in Section 2.3. The consultant should select the proper measures and determine what wood should be replaced to re-establish the integrity of the structure and prevent further fungal growth. In cases where the occupants are experiencing severe chemical sensitivity, any fungicides to be used should first be checked with a doctor. Electrical wiring and receptacle boxes should be checked for any degradation caused by the installation of the UFFI. Such degradation may be in the form of mechanical damage to or corrosion of wires, boxes, connectors or other components.

- treat all wood surfaces in the cavity

All wood, including sheathing, should be treated with the 3 per cent sodium bisulfite solution using the procedure described at the beginning of this section. If the removal is taking place in winter or cold weather the temperature of the living space should be elevated to 23°C and the house ventilated to accelerate drying.

- insulate the cavity and install an air/vapour barrier

Once dry, the cavity should be re-insulated with batt type insulation and a 6 mil polyethylene air/vapour barrier installed. The polyethylene should be sealed to the top and bottom wall plates and to the end studs with a durable non-hardening sealant and staples. Where possible the polyethylene should be continuous behind interior partitions that are framed into the exterior wall. Joints between the polyethylene sheets should be located over a stud and sealed with the same sealant.

Electrical outlets should be wrapped or enclosed in airtight plastic boxes to provide an effective air seal. Gaskets installed behind the cover plate can also be used.

- install interior finish

The choice of interior finish should be made carefully to avoid products which emit formaldehyde. In cases where there is no severe chemical sensitivity, gypsum board is the most appropriate. In cases of severe chemical sensitivity, the installation of a lath and plaster interior finish may be required to further avoid contribution of chemicals, from the finish, to the air of the living space. The interior finish can be sealed to the floor to act as a second line of defence against air infiltration.

(ii) Removal of UFFI from the exterior

Removal of the UFFI from the exterior also has several advantages. The process is less disruptive to the occupants and normal household activities. Sometimes fewer layers of materials are required to be removed or a structural layer prevents removal from the inside. Less protection of belongings is needed and interior redecorating is not required. The procedure for removal from the outside should include the following steps:

- pressurize living space

In some cases, removal of the UFFI from the exterior has resulted in a fine UFFI dust deposit on all interior surfaces. The same air leakage paths which brought formaldehyde gas into the living space, can allow air containing small particles of UFFI to enter the living space during removal. Pressurization will reduce the infiltration of particulate matter. Fans temporarily placed in windows or doors will provide adequate pressurization during the removal process. Another way to reduce the amount of UFFI dust entering the living space is to seal the inside surface of the walls, as discussed in Section 3.2, before the removal of the UFFI. The sealing of the inside surface at some point is necessary so the money is not wasted. This may be done in conjunction with temporary pressurization during the removal process.

- remove exterior cladding, sheathing, UFFI and any other material such as batt insulation

  Any exterior cladding that has not been in contact with the UFFI can be reused if desired. Where UFFI was placed between brick veneer and the exterior sheathing, the bricks will be impregnated with resin but could be reused if a properly ventilated air space is provided between the brick and the sheathing paper. A set of weep holes at the bottom of the wall and vent holes at the top should provide adequate ventilation. In cases of severe chemical sensitivity, replacement of the contaminated bricks should be considered. Sheathing in contact with the UFFI should be discarded. Other material in the cavity such as batts should be discarded since they will probably be contaminated. Scrap material can be placed in large rubbish containers of the type used by contractors. A cover for the container is required to prevent the UFFI from blowing out during windy weather.

- check floor spaces, ceilings and interior partitions

  Ensure all UFFI is removed. The UFFI may have been put in these locations accidentally because of the way in which the house was built.

- brush, vacuum and inspect the cavity

  The cavity surfaces should be brushed and vacuumed to remove all residual foam. The wood should be checked for evidence of fungal growth. If fungus is present a consulting engineer or architect should be retained as discussed in Section 2.3. A consultant should select the proper measures and determine what wood should be replaced to re-establish the integrity of the structure and prevent further fungal growth. In cases of severe chemical sensitivity, any fungicide to be used should first be checked with a doctor. Electrical wiring and receptacle boxes should be checked for any degradation caused by the installation of the UFFI. Such degradation might be in the form of mechanical damage to or corrosion of wires, boxes, connectors or other components.

- treat all wood surfaces in the cavity

  All wood should be treated with the 3 per cent sodium bisulfite solution using the procedure described at the beginning of this Section. If removal is taking place in winter, shelters may be required to maintain temperatures high enough for drying. Interior gypsum board or lath and plaster should not be treated with the solution. A limited amount of wetting of wood lath, however, should not damage the plaster finish.

- improve the air barrier and re-insulate the cavity.

  An attempt should be made before re-insulating to improve the air seal at the interior surface of the wall. The joints between the wall plate, subflooring, and header joist should be sealed. If this is not possible from the exterior it should be done from the interior as described in Section 3.2. Joints where interior partitions frame into the exterior wall should be sealed. Electrical outlets can be wrapped or enclosed as discussed in removal from the inside. Since construction details vary considerably, careful study and consideration may be required to seal the wall. High solvent compounds should not be sprayed into the cavity to act as an air seal since they may introduce new or unwanted chemicals to the living space. Batt type insulation should be used to re-insulate.

- install new sheathing, sheathing paper and exterior cladding.

  Provincial building codes, which identify minimum requirements for sheathing and exterior cladding, must be followed. The municipal building inspector can be contacted for this information. Although sheathing paper is not always required in the code, at least one layer, applied horizontally and lapped 100 mm, is a recommended practice.

3.7 Removing Residual Formaldehyde from Living Space

In cases where medical problems were involved the final step in the series of remedial measures is cleaning the living space. This would include the following:

- wash clothes and linens

  Almost all the formaldehyde which may have been adsorbed (due to the UFFI) will be removed by the washing.

- clean carpets and upholstered furniture

  A commercial hot water carpet cleaner should be used. If this is not possible, carpets and upholstered furniture should be cleaned by a professional cleaner. Foam from covered cushions should be aired outside.

- wash walls

  Use soap and water and rinse with clear water. This will remove most of the formaldehyde clinging to the surface.

- wash cupboards and other enclosed spaces

  Use soap and water if strong odours are present. If there are no odours, simply wipe and air.

- vacuum furnace air ducts and replace furnace filters

  This will remove dust or UFFI particles if the furnace was operating during removal of the UFFI.

3.8 SUMMARY - Remedial Measures

As can be appreciated from the discussion of remedial measures, there are a number of factors to be understood for each measure. Some measures will be more suited for certain construction types or individual house features. The remedial measures are most effective when combined.

With the intent of the different measures explained, and with the data obtained in the problem investigation stage, a series of minimum action steps can be selected with the aid of Appendix A. If there is any doubt about the seriousness of a situation, additional measures beyond the minimum recommended should be taken. In some cases interim measures should be undertaken pending the completion of measurements or selection and completion of the remedial measures. These measures are also discussed in Section 4 and Appendix A.

In certain cases, the formaldehyde gas concentration in the house should be rechecked two or three days after the remedial measures have been completed. When the UFFI is left in the cavity, the formaldehyde gas concentration in the cavity should also be checked. The ratio of formaldehyde gas concentration in the living space to the cavity concentration can be compared with the original tests to provide an indication of the success of the measures. In cases where the UFFI is removed, the final concentration in the living space should be comparable to the ambient concentration taken at the same time. If concentrations are not near ambient (in most cases below 0.01 to 0.02 ppm), further measures should be considered.

4.0 PREVENTIVE MEASURES

In the majority of homes with UFFI there will be adequate separation between the UFFI and the living space to keep formaldehyde concentrations low in most weather conditions. Experience with the more recent formulations of UFFI is limited to a few short-term observations so there is no certainty that changes will not occur. The potential for formaldehyde gas exposure can be determined by measuring the formaldehyde gas concentration in the cavities and the moisture content of the wood in the wall cavity. Occupants should take steps to reduce the possibility of exposure to elevated concentrations of formaldehyde gas. Table A2 provides a general guide to the minimum preventive measures which should be considered. These preventive measures are discussed in Section 3. The minimum measure that should be taken is the sealing of cracks, holes, joints or other openings in the interior surface of the exterior wall through which air containing formaldehyde may leak into the living space. This is discussed in detail in Section 3.2.

Where the foam has been installed in an accessible attic, the insulation should be removed. If the attic is inaccessible, the ceiling should at least be carefully sealed. This may require the application of a sealed polyethylene air/vapour barrier and a new finish if the existing finish is not satisfactory. The space may be vented to the outside possibly with a thermostatically controlled exhaust fan installed for operation in warm weather only. Power fans should not be put into cathedral ceilings or flat roofs unless cross ventilation allows the air to reach the fan. UFFI installed in internal partitions should be sealed or removed.

5.0 PROTECTIVE MEASURES FOR WORKERS

The risk to persons working with the foam or other materials that have been in contact with it can be reduced by taking a few precautions:

- persons sensitive or allergic to formaldehyde gas or other toxic materials should not participate in this work.

- wear rubber gloves, eye goggles, suitable dust mask, long-sleeve shirt and full-length pants when handling the UFFI, material in contact with the UFFI or liquid from it.

- wear rubber gloves, eye goggles, a suitable mask designed for filtering toxic gases and dusts, a long-sleeve shirt and full-length pants when mixing, handling or applying the sodium bisulfite solution.

- ventilate the house when removing UFFI and when spraying the sodium bisulfite solution.

- any workers encountering physical discomfort, rashes or other unexplained medical symptoms should discontinue work on UFFI removal immediately.

- any worker inhaling the concentrated sodium bisulfite powder should consult a doctor or a poison control centre immediately to determine the type of treatment necessary.

If there are any questions regarding safety equipment, local stores selling safety equipment or provincial labour departments should be consulted. Contractors should contact the provincial Workmen's Compensation Board prior to starting work to ensure safety precautions to be taken are satisfactory to the Board.

6.0 CONCLUSIONS

The measures and tests described in this Building Practice Note are intended to help homeowners, contractors and UFFI manufacturers determine if a problem exists and how it might be solved. It is advisable to keep a photographic record of visible problems and remedial measures and record observations during remedial work for future reference.

With the preceding knowledge, it is suggested that a problem be addressed as follows:

(1) Measure formaldehyde gas concentration in the wall cavities, and living space when appropriate, and the moisture content of wood in the wall cavity

(2) Consult Appendix A for assistance in selection of remedial measures

(3) Refer to Section 3 of this paper for details on remedial measures presented in this Note

(4) Conduct remedial measures

(5) After completion of the remedial measures, measure the formaldehyde gas concentration in the wall cavities and living space if UFFI was left in the cavity. Compare the ratio of the living space concentration to the wall cavity concentration before and after remedial measures. If the UFFI was removed the formaldehyde gas concentration in the air of the living space should be comparable to ambient concentrations

(6) Perform additional remedial measures where necessary

The remedial measures discussed are based on sound building science principles and the current knowledge of UFFI. Their application to the wide variety of houses experiencing problems is limited. The authors welcome reports on the application of the remedial measures, particularly on any difficulties that were encountered, and on the effectiveness in overcoming any problems.

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APPENDIX A

SELECTION OF REMEDIAL MEASURES

Each home insulated with UFFI has unique characteristics and is operated in different ways. A number of measurements will be needed in each house to assist in the selection of remedial or preventive measures. These measurements include the formaldehyde gas concentration in at least 10 wall cavities and moisture content of the wood stud or bottom plate in the same wall cavities. In some cases measurement of the formaldehyde gas concentration in the air of the living space will also be required. Minimum Action Steps and Remedial Measures are presented in Tables A1 to A4 based on measurements from the stud spaces of conventional platform or balloon frame construction. The general concept and strategies can be considered for other situations but may require the aid of a consulting engineer or architect.

The intent of the recommended remedial measures is to reduce the amount of formaldehyde gas, from UFFI, entering the living space. Since health experts have so far been unable to establish the safe concentration for residential environments, the only practical concentration to attempt to achieve is the ambient concentration which would exist if the UFFI was not emitting formaldehyde gas. The Action Steps including remedial measures outlined in the tables, therefore, should be considered as minimum measures. Homeowners are encouraged to go beyond the minimum measures when it is feasible to do so.

Use of Tables A1 to A4

The formaldehyde gas emission rate from UFFI is affected by both temperature and relative humidity. As the temperature and humidity rise, so will the rate of formaldehyde gas emission. The concentration in the cavity will be directly related to the emission rate. This causes some difficulty when trying to interpret the measurements of formaldehyde gas in the wall cavity. The measurements might be made anytime throughout the year and cannot be made under a standard set of conditions. Measurements made under various temperature and relative humidity conditions must be correlated to the basic relationships between formaldehyde generation rate, relative humidity and temperature in the air of the wall cavities. The moisture content of the air in the cavity should be very nearly equal to the moisture content in the outdoor air and so will vary with weather conditions. The outdoor temperature and relative humidity should be measured for each set of measurements. They can also be obtained from the Atmospheric Environment Service of Environment Canada.

Table A1 outlines the Action Steps and Remedial Measures that should be taken if the moisture content of the wood in the wall cavity is over 20%. In Tables A2 to A4, the required Action Steps and Remedial Measures are based on the "Class" of the UFFI. Five classes, A to E, have been identified. To determine the UFFI class, and thus what action should be taken, Figure A1 should be used. This Figure relates the formaldehyde gas concentration to temperature and relative humidity; it is based on few data and will be refined as additional information becomes available.

The following outline of the procedure uses the data cited in Example 1, details of which are presented later. These data are: temperature -- 15°C; relative humidity -- 70%; formaldehyde gas concentration (ppm) -- 0.5. To determine the UFFI class using Fig. A1, proceed as follows: draw a vertical line upwards from the Example temperature (15°C) to where it meets the curved relative humidity line (in this case the RH is 70%). Project a horizontal line from this point to the right to indicate the moisture content on the vertical scale (7.5 kg/kg × 10^3). Continue this line to the graph on the right to where it meets the vertical line drawn upwards from the value 0.5 -- the formaldehyde gas concentration in the wall cavities. The point at which these two lines intersect, designates the class of UFFI -- in this case, Class A.

The classes have been defined on the basis of 0°C and 100% relative humidity (moisture content of 4 kg/kg × 10^3 dry air). At these conditions the regions bracket the following wall cavity concentrations:

A - under 0.5 ppm
B - 0.5 ppm to 2 ppm
C - 2 ppm to 4 ppm
D - 4 ppm to 6 ppm
E - over 6 ppm

Once the class has been identified for a particular situation the appropriate series of action steps can be selected from the tables.

Table A2 outlines the minimum remedial measures that, barring any complications, should reduce the formaldehyde gas concentration in the living space to near ambient concentrations. Recognizing the uncertainties involved every effort has been made to err on the safe side. Where odours exist it is reasonable to take more caution than if no odour existed. Table A3 gives measures that have a greater safety margin than those in Table A2. Table A4 has even a greater safety margin than the first two because persons suffering medical problems suspected of being related to the UFFI can be more sensitive and can be exposed to a greater risk. The differences between the tables are readily identified by comparing the actions for a corresponding class in each of them.

It is emphasized that the people, homes, and material are unique and the ultimate decision on the remedial measures lies with the occupants. If after taking a series of remedial measures there is insufficient improvement in an occupant's health, additional measures are recommended.

In some cases interim measures should be undertaken pending the completion of measurements or selection and completion of remedial measures. Interim measures that can be made include pressurizing the house in the summer with a fan blowing through a window, the taping of baseboards, the sealing of electrical outlets to reduce infiltration, or the temporary relocation of the affected occupants. Relocation for a week or more, is useful in showing if an improvement in health can be detected when the person is moved to a more formaldehyde-free environment.

Adequacy or effectiveness of remedial measures can be confirmed by repeating measurements of formaldehyde gas concentrations in the wall cavity and the living space. The ratio of the concentration in the living space to that of the wall cavity after remedial measures should be much lower than that determined before the remedial measures were taken. In cases where the UFFI is removed, the concentration of formaldehyde gas in the living space after remedial measures should be comparable to the concentrations in the outside air at the same time. If improvements are not sufficient, additional measures will be required.

The following are key points regarding the suggested action steps:

- where medical symptoms are suspected of being related to UFFI, the concentration of formaldehyde gas in the living space and wall cavity should be determined before and after remedial measures.
- when fungal growth is identified, a consultant must determine whether and how to treat the wood, and whether the steps outlined in the tables are adequate.
- if the measurements of the concentration of formaldehyde gas in the cavities differ, a combination of remedial measures may be required. The measures chosen may differ from one area to another area in the house or be determined by the average formaldehyde gas concentration measured. Example 2 highlights this point.

The following examples are based on a number of actual cases but have been simplified to illustrate the use of the remedial measures outlined in the tables. Since actual cases may involve other factors not mentioned, further measures may be required in actual cases.

Example 1

Mr. Smith did not have any problems which could be identified with exposure to formaldehyde gas but wanted to take some precautionary measures.

(i) Mr. Smith borrowed a moisture meter and measured the moisture content of the wood in 10 stud spaces insulated with UFFI.

The readings all indicated a moisture content of below 10%.

(ii) He purchased an air sampling pump and tubes for just over $100 and measured the formaldehyde concentration in the same cavities.

The readings were all below 0.5 ppm (parts per million) indicating that the foam in the cavities tested was of fairly uniform quality. The temperature and relative humidity on the day of measurements was 15°C and 70% respectively. Using Figure A1 the intersection point fell in class A. This indicates the concentration in the cavities was low. Since there were no health problems or odours Table A2 was used to identify the minimum remedial measures for Class A.

(iii) He sealed all cracks and openings between the cavities and living spaces.

The infiltration of air through the wall cavities was reduced and thus reduced the potential entry of formaldehyde-laden air.

Since the original measurements were made on a day with moderate temperature and relative humidity, additional measurements of formaldehyde gas in the stud space were taken in the summer on a hot day. The results were such that the house remained in Class A; no additional remedial measures were necessary at that time. If the concentration were higher, additional measures would be warranted. The sampling pump was used for periodic checks of the cavity concentration and a careful record kept of the measurements and the class from Figure A1.

Example 2

Mrs. Jones' child was experiencing medical problems which were believed to be related to the UFFI.

(i) the child was taken to a physician

The doctor was unable to say whether exposure to formaldehyde gas was the cause of the medical problems but did not discount the possibility.

(ii) the general ventilation in the home was increased immediately by installing a fan in a window to blow air into the house.

The exposure to formaldehyde was reduced by temporary means to prevent over-exposure while it was determined whether formaldehyde gas was the cause of the child's problems.

(iii) the child was sent to spend a week with relatives who did not have UFFI in their homes.

An improvement in the child's symptoms was noticed indicating that the symptoms were likely related to the environment in his own home.

(iv) A consultant was hired to measure the formaldehyde gas concentration in the air of the living space. The operation of the house for the period leading up to the test was specified by the consultant.

The formaldehyde concentration in the air of the living space was 0.2 ppm. This measurement was made to check that the formaldehyde was present at a concentration significantly higher than the ambient concentration outside of 0.01 ppm. It was also made to compare with later readings to determine the effectiveness of remedial measures.

(v) the consultant also measured the formaldehyde gas concentrations in at least 10 stud spaces

The readings for 3 out of 4 walls were below 1 ppm but in the fourth wall they averaged 10 ppm. For the temperature and humidity conditions present, the fourth wall was in class E of Fig. A1. This indicated that the problem was localized to the one wall and that removal would be necessary as per class E, Table A4. The conditions in the other walls were in class B.

(vi) The moisture content of the wood in all four walls was also measured.

The wood was dry indicating the high formaldehyde gas concentration was not caused by the presence of moisture.

(vii) the consultant cut a test opening to remove a sample of the gypsum board for laboratory analysis of formaldehyde emission.

There was very little formaldehyde gas emitted by the gypsum board so the removal of the UFFI from the 4th wall could be done from either the inside or outside.

(viii) Mrs. Jones hired a contractor to remove the UFFI from the exterior under the supervision of the consultant.

A copy of NRC Building Practice Notes 19 and 23 on UFFI were provided to the contractor to outline the procedure to be followed and to emphasise the importance of each step. The rooms of the house along the wall where the UFFI was being removed were pressurized during removal to reduce the amount of UFFI dust entering the living space. Notes and photographs were taken to retain a record of the remedial work.

(ix) the contractor was also hired to seal all the cracks and areas of air infiltration on all four walls.

Since it was difficult to seal the fourth wall from the outside even with the wall open, it was sealed from the inside in the same way as the three still containing the UFFI.

(x) a small squirrel cage fan was permanently installed in the basement.

By blowing outside air into the basement the negative pressure difference was reduced. A small electric heater was installed near the discharge of the fan to heat the incoming air in the winter. A separate fan was necessary for this measure because the house was heated by a hot water system and the furnace had no air circulating fan.

(xi) Mrs. Jones washed the ceilings, walls, floors, laundered or dry-cleaned the linens and curtains, vacuumed the rugs and shampooed the upholstery.

Most of the formaldehyde clinging to the room surfaces and adsorbed on the fabrics in the living space was removed by this measure.

(xii) a second measurement of formaldehyde gas concentration in the living spaces and wall cavities in the three walls with UFFI was made by the consultant.

After these measures, the concentration in the living space was near ambient and the ratio of concentrations between the living space and the wall cavities much smaller. The child's health also showed signs of improvement.

Had the child continued to suffer, a doctor should again be consulted and consideration given to implementing other measures such as installation of a heat exchanger coupled with the fan to bring the concentration in the living space closer to ambient. A special air filter system might be required to lower the concentration below ambient concentrations.

TABLE A1. ACTION STEPS AND REMEDIAL MEASURES --

Moisture Content of Wood Over 20%

Action Steps & Remedial Measures	Reference(s) to text
1. Cut test opening in stud space where moisture content is highest or where there is visible evidence of fungus growth	6, 7, B4
- Submit samples of wood, UFFI and other infected material for fungus identification	B4
2. If fungus growth is found, hire a consultant to deal with problems	6
3. If no serious fungus growth is found, proceed with drying cavity as follows:	
(a) Check (or have consultant check) for sources of moisture and correct as appropriate	B6
(b) Dry section of wall until wood moisture content is between 10 and 15%	B6
(c) Close cavity	
(d) At least one day after step (c), recheck formaldehyde gas concentration in the wall cavity to determine effect of drying on gas concentration.	8, 10
Consult Tables A2 to A4 to identify the remedial measures required.	A1 - A6
If removal of the UFFI is warranted, there is no benefit from drying all cavities.	
(e) If removal is not warranted, dry all cavities with moisture content above 20%	B6
(f) Close cavities	
- Recheck formaldehyde gas concentration in cavities	8, 10
(g) Proceed with remedial measures to control formaldehyde gas based on new measurements	Tables A2-A4

TABLE A2. ACTION STEPS AND REMEDIAL MEASURES --

No Medical Problems, No Odour from UFFI

Class, from Fig.A1	Action Steps & Remedial Measures	Reference(s) to text
A	- seal exterior wall	18-20
B	- seal exterior wall	18-20
	- increase ventilation by use of forced air furnace	20-22
C	- seal exterior wall	18-20
	- seal interior partitions	20
	- increase ventilation by use of forced air furnace	20-22
D	- seal exterior wall	18-20
	- seal interior partitions	20
	- increase ventilation by use of forced air furnace	20-22
	- measure formaldehyde gas concentration in living space	8, 10, B1, B2
	if not near ambient:	31, A1, A3
	install forced ventilation with or without heat exchanger	22-23
E	- measure formaldehyde gas concentration in living space	8, 10, B1, B2
	- seal exterior wall	18-20
	- seal interior partitions	20
	- increase ventilation by:	
	forced air furnace	20-22
	OR	
	forced ventilation with or without heat exchanger	22-23
	- remeasure formaldehyde gas concentration in living space	8, 10, B1, B2
	if not near ambient:	31, A1, A3
	install chemisorbent filter	23-24
	OR	
	remove UFFI	25-31

TABLE A3. ACTION STEPS AND REMEDIAL MEASURES --

Odour from UFFI Present

Class, from Fig.A1	Action Steps & Remedial Measures	Reference(s) to text
A	- seal exterior wall	18-20
	- increase ventilation by use of forced air furnace	20-22
B	- seal exterior wall	18-20
	- seal interior partitions	20
	- increase ventilation by use of forced air furnace	20-22
C	- seal exterior wall	18-20
	- seal interior partitions	20
	- increase ventilation by:	
	forced air furnace OR forced ventilation	20-22, 22-23
D	- measure formaldehyde gas concentration in living space	8, 10, B1, B2
	- seal exterior wall	18-20
	- seal interior partitions	20
	- increase ventilation by:	
	forced air furnace OR forced ventilation	20-22, 22-23
	- remeasure formaldehyde gas concentration in living space	8, 10, B1, B2
	if not near ambient:	31, A1, A3
	increase forced ventilation with heat exchanger	22-23
	OR	
	install chemisorbent air filter	23-24
E	- measure formaldehyde gas concentration in living space	8, 10, B1, B2
	- seal exterior wall	18-20
	- increase ventilation by:	
	forced ventilation	22
	OR	
	forced ventilation with heat exchanger	22-23
	- remeasure formaldehyde gas concentration in living space	8, 10, B1, B2
	if near ambient, proceed with sealing interior partitions	20
	if not near ambient:	31, A1, A3
	install chemisorbent filter	23-24
	OR	
	remove UFFI	25-31

TABLE A4. ACTION STEPS AND REMEDIAL MEASURES --

Medical Symptoms Apparently Related to UFFI

NOTE: In cases involving medical problems, the formaldehyde gas concentration in the air of the living space should be checked before proceeding with remedial measures.

Class, from Fig.A1	Action Steps & Remedial Measures	Reference(s) to text
A	- seal exterior wall	18-20
	- increase ventilation by use of forced air furnace	20-22
	- clean interior surfaces	30-31
	- remeasure formaldehyde gas concentration in air of living space	8, 10, B1, B2
	if not near ambient or persons still reacting:	31, A1, A3
	seal interior partitions	20
	remeasure formaldehyde gas concentration in air of living space	8, 10, B1, B2
B	- seal exterior wall	18-20
	- seal interior partitions	20
	- increase ventilation by use of forced air furnace	20-22
	- clean interior surfaces	30-31
	- remeasure formaldehyde gas concentration in air of living space	8, 10, B1, B2
	if not near ambient or persons still reacting:	31, A1, A3
	provide forced ventilation with or without heat exchanger	22-23
	OR	
	install chemisorbent filter	23-24
C	- seal exterior wall	18-20
	- seal interior partitions	20
	- provide forced ventilation	22-23
	- clean interior surfaces	30-31
	- remeasure formaldehyde gas concentration in air of living space	8, 10, B1, B2
	if not near ambient or persons still reacting:	31, A1, A3
	increase forced ventilation with heat exchanger	22-23
	OR	
	install chemisorbent filter	23-24
D	- seal exterior wall	18-20
	- seal interior partitions	20
	- provide forced ventilation with heat exchanger	22-23
	- clean interior surfaces	30-31
	- remeasure formaldehyde gas concentration in air of living space	8, 10, B1, B2
	if not near ambient or persons still reacting:	31, A1, A3
	install chemisorbent filter	23-24
	OR	
	remove UFFI	25-31
E	- sample material from wall for formaldehyde emission test	11, B4
	- remove UFFI	25-31
	- clean interior surfaces	30-31
	- remeasure formaldehyde gas concentration in air of living space	8, 10, B1, B2
	if not near ambient or persons still reacting:	31, A1, A3
	check for UFFI missed in other locations	26, D2
	check for internal sources of formaldehyde gas, e.g. furniture	26

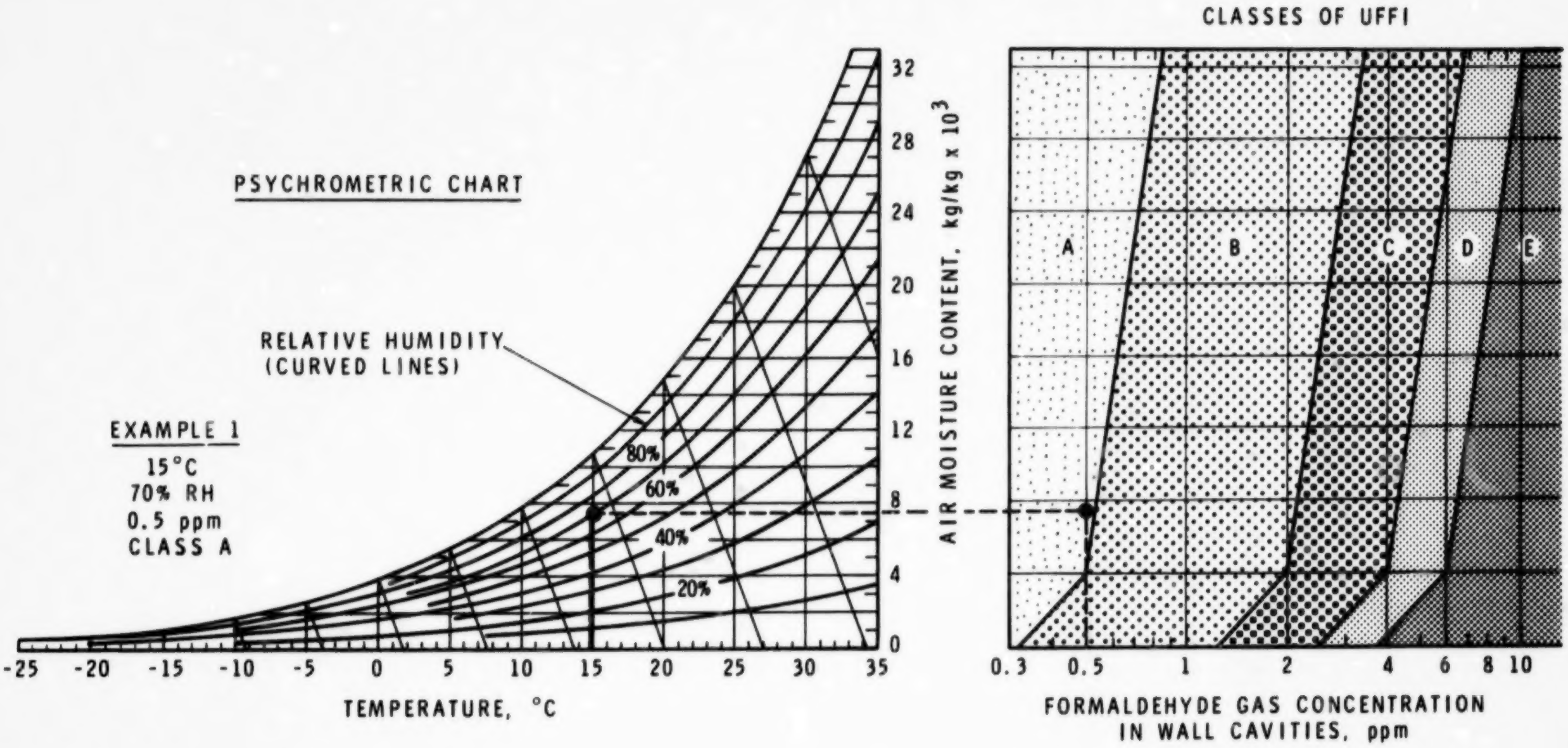

FIGURE A1

RELATIONSHIP OF FORMALDEHYDE GAS CONCENTRATION IN WALL CAVITIES, TEMPERATURE AND RELATIVE HUMIDITY TO CLASS OF UFFI

APPENDIX B

SUMMARIES OF SUBJECTS TO BE COVERED BY FUTURE PUBLICATIONS ON UFFI

1. Measurement of Moisture Content in Wood

Moisture meters are simple electrical ohmmeters which measure the electrical resistance between two needle-like probes. Probes are available with needles of various lengths. Probes having insulated needles except for the tips can be driven through the gypsum board or lath and plaster into the wood stud or plate at the bottom of the cavity and a reading of the moisture content taken. If the probes are too short to penetrate through the interior finish, the baseboard should be removed and a section of interior finish cut away to allow the probe to enter the wood. This should be done so that the cut-away and any sealing is covered when the baseboard is reapplied.

2. Measurement of Formaldehyde in the Living Space

NIOSH* Chromotropic Acid Method

The most common method of measuring formaldehyde gas in the living space is the NIOSH chromotropic acid method. The method, simply stated, involves: i) passing a known volume of air through a solution that collects the formaldehyde gas from the air and ii) developing the solution using a laboratory procedure to yield a coloured solution, then reading the intensity of the colour using photometric methods and based on the intensity, determining the formaldehyde concentration. The sampling time is normally a number of hours to allow sufficient volume of air to pass through the solution.

New Methods

Instrument companies are in the process of developing detectors with improved accuracy, sensitivity, portability and more convenient sampling procedures. Detectors operating on the principle of gas diffusion through a membrane or tubes into a solution are receiving greater recognition.

House Preparation

When measuring the concentration of formaldehyde gas in the living space, it is preferable that it be done under worst-case conditions. Unfortunately, the interrelationship of the mechanisms causing high formaldehyde gas concentrations in the living space are not completely understood so are difficult to predict. Worst-case weather conditions seldom occur when measurements are required. Worst-case conditions "under prevailing foam and weather conditions" are therefore the best that can be readily measured. Guidelines to encourage the worst-case conditions are offered.

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*National Institute of Occupational Safety and Health

In each case the testing agency must carefully consider unique features of the building which may affect the results. The preparation of the house should be adjusted as appropriate. The following is offered as a general guide:

a) For 18 hours before and during the test:

- maintain the house temperature at a steady temperature of at least 20°C (no night set-back of thermostat)
- keep all windows, fireplaces and vents closed
- turn circulating fan on forced air furnaces to normal rather than summer circulation
- do not operate ventilation fans, generate any smoke by frying or broiling, or operate automobiles in attached garages
- do not use gas stoves, fireplaces or other combustion equipment with the exception of the furnace.
- do not paint
- do not smoke in the house

b) During the Test:

- take measurements only if windspeeds are less than 25 km/h
- take air sample in mid-afternoon if in winter; morning or mid-afternoon if in summer.
- set thermostat back to 14°C to ensure furnace does not operate during sampling; operate air conditioners with 100% recirculation.

c) Number of Samples:

- a minimum of one air sample per floor should be taken close to the centre of the floor. A measurement of the outside ambient concentration is not essential unless no information is available for that region or unusual conditions exist.

The UFFI may emit gases other than formaldehyde which can cause similar reactions in the occupants and may also interfere with the measurement of formaldehyde. In cases where the medical reactions seem to be related to the environment in the living space, the formaldehyde gas concentration seems too low to have been the cause, and investigations do not identify any fungal growth, measurements should be made for other gases. Other sources of gas such as sewer gas, exhaust from furnaces or vapours from insecticides should be investigated.

3. Measurement of Formaldehyde in the Wall Cavity

There are two types of hand-held instruments for measuring formaldehyde which provide results in a short time period. These are simple to operate and the measurements are inexpensive.

The first type is a hand-operated air-sampling pump using gas detection tubes. A specific volume of air is pumped through a detection tube containing chemicals which react with one gas or a family of gases and produce a known colour change. The gas concentration is determined by either of two methods and depends on the make of equipment. Either the volume of air required to produce a specific colour change in the tube is measured or the length of the column of chemical that changes colour is measured. The sensitivity of the gas detection tube and the range varies from one manufacturer to another. The following gas detection tubes are currently available:

Company		Range
Drager:	high range	2 - 50 ppm
	low range	0.5 - 10 ppm
Gastec		2 - 20 ppm
Kitagawa		1 - 35 ppm
Mine Safety Appliances		1 - 100 ppm

The accuracy of these detectors is poorer than NIOSH but they do provide a reasonable indication of the concentrations. The tubes are sensitive to temperature and humidity, so the manufacturer's instructions should be closely followed. In some cases, the colour change in the tube will be different than that specified for formaldehyde gas. For example in the Drager system the proper colour change is from white to pink whereas the presence of other specific gases can cause a colour change from white to orange, yellow or brown. Whenever this occurs, other types of tubes or specialized sampling equipment will be required to identify the gases present. Heavy gases may collect at the bottom of the cavity so a second sample at least 1.5 m higher in the same cavity may be required to determine formaldehyde gas concentration.

To make a mesurement using a gas detection tube instrument, a hole the size of the detection tube is drilled into the stud space and well into the foam. The detection tube is inserted immediately into the wall cavity and an air sample taken. Upon removal of the tube the hole should be immediately covered with tape. Care should be taken to prevent short-circuiting of air from the room into the hole in which the detection tube is inserted. If the hole drilled is too large, it should be covered with a piece of tape and the detection tube inserted through a smaller hole punctured in the tape. Daylight from a window or a standard light source should be used to observe the colour change in the tube. While the tube is removed to observe the colour the hole should be temporarily covered with tape.

A newer instrument, developed by Lion Laboratories in collaboration with Ciba-Geigy Plastics and Additives Company, is the Formaldemeter. This instrument uses a fuel cell detector and provides the reading in a digital display. The accuracy is similar to that of the detection tubes. The concentration is equal to the peak value displayed after approximately 20 seconds. Like the detection tubes, this device is also subject to interferences from other gases. This may be indicated by a peak reading being displayed at considerably shorter or longer than 20 seconds. A number of minutes must be left between readings to allow the fuel cell to discharge. The time required depends on the concentration measured.

With the Formaldemeter, only a small air sample is required. A needle similar to the type used to fill footballs and basketballs can be used for walls which do not have multilayer sheathing. The needle is inserted into the wall cavity through a small pilot hole the same size as the needle and then connected to a pump by a short length of tubing. The Formaldemeter air sample is taken from a sampling port in the tubing after the flow has come to equilibrium and the pump shut off. A hand pump can also be used.

Cavities, including ceiling spaces, can be checked with either method to determine if a problem is general throughout the house or localized in a few cavities. Measuring concentrations in the ceiling cavity near the wall may indicate the presence of UFFI in the ceiling or floor space if the concentrations are comparable to the wall cavity measurements.

4. Test Opening and Material Sampling

Test openings will generally be used for the following:

- obtaining samples for fungal identification
- checking for visible problems
- sampling interior sheathing for determination of formaldehyde gas emission in a laboratory

Where possible, a location should be selected that is easily repaired and the finish not critical to a room's appearance. This might be in a closet or behind a piece of furniture. The location of electrical outlets and wires in the basement should be used to determine if there are electrical wires in the cavity before cutting. The opening should span a stud space, be at least 300 mm high, and should be located at the bottom of the wall just above the baseboard so that the bottom wall plate can be observed (Figure B-1). Each of the materials removed in making the opening, such as gypsum board (or lath and plaster), UFFI and sheathing should be placed in separate sealed plastic bags. The bags should be labeled and kept in case they are required for the formaldehyde emission measurements. The surfaces of the bottom plate and studs should be brushed clean and checked for rot, fungal growth or unusual discoloration.

In the following situations samples of material from the test opening (UFFI, wood, paper) should be submitted to a fungal identification specialist:

- where the wood is discolored and/or feels damp several large slivers should be obtained
- where the UFFI, which is normally white, off-white, or blue, has turned grey, black or green, a small piece (less than 100 mm square and the thickness of the cavity) of the discolored foam should be obtained

- where fungal growth or insect infestation is evident, small samples (less than 100 mm square) of each kind of organic material in the test opening should be obtained. These would include slivers of wood from studs, paper from any existing insulation, UFFI, and a 25 mm square of exterior sheathing material.

Agriculture Canada provides a fungal identification service for the Canadian public. The specialist will determine the species of fungus, food source and whether the fungus has been active or dormant. At the time of writing this publication there was no charge for the service.

The samples to be submitted for fungal identification should be placed in separate clean unused plastic bags punctured to supply air to the fungus and to prevent the humidity in the bag from rising too high. They should be shipped to the following address with complete information on when the UFFI was installed, pictures if available, date samples were removed, location in structure and a description of the building construction:

Director, Biosystematic Research Institute,
National Identification Service,
Agriculture Canada
Wm Saunders Building,
Central Experimental Farm,
Ottawa, Ontario. K1A 0C6

After all observations have been made and samples removed, the opening should be filled with a batt-type insulation and temporarily sealed by taping polyethylene over the opening. Once the investigation of the problem is complete and the remedial measures identified, the test opening can be permanently repaired as appropriate.

5. Optical Probes

Optical probes for use in inspecting wall or other cavities in the building envelope are similar to the types used by the medical profession. They allow visual or photographic observations of the cavity without causing serious damage to the sheathing.

The probe is inserted through a hole approximately 15 mm in diameter. The hole is easily repaired and the surface refinished so that little evidence of entry is apparent. When the presence of moisture is suspected, a series of cavities can be checked by drilling a hole just above the wall's bottom plate, moving the insulation away from the bottom plate with a screwdriver or wire probe, inserting the optical probe and inspecting the plate. Where moisture or fungal growth is apparent, the cavities should be opened for further investigation.

Optical probes are expensive and so are probably only practical for use by consultants and contractors.

6. Drying Wet Cavities

Before a cavity is dried the source of moisture should be identified and, if it is rain or air leakage, corrected. The quickest way to dry the wet cavity is to force warm dry air to flow through the cavity to the outside. It is not always possible to preheat the air used for drying. It would be advisable to experiment with a section of the wall to determine if drying is effective and then to remeasure the concentration of formaldehyde gas in the cavity. This will indicate whether moisture was the cause of high concentrations. If, after drying, the formaldehyde gas concentrations are still high enough to warrant removal of the UFFI, there is no benefit in trying to dry all the cavities unless the high concentrations are localized to one part of the house. The following techniques, although not fully evaluated at time of publication, will provide an indication of various methods which could be considered.

Method 1

- forced ventilation by connecting stud spaces to a manifold and drawing air through the cavity and discharging to the atmosphere

Method 2

- drill a hole into each stud space through the inside surface about 50 mm above the floor level. Using a fan, in the summer pressurize the living space or in the winter depressurize the living space. Depending on formaldehyde concentrations, the occupants may need to be temporarily relocated if the house is being depressurized.

Method 3

- if exterior is siding, open the wall cavity from the exterior at the top and bottom to allow air to circulate freely. The openings must be protected from the weather and the interior surface of the wall sealed to reduce the uncontrolled flow of air into the living space.

Once the cavity is dry (10 to 15% moisture content) the holes through the sheathing should be sealed and cladding restored.

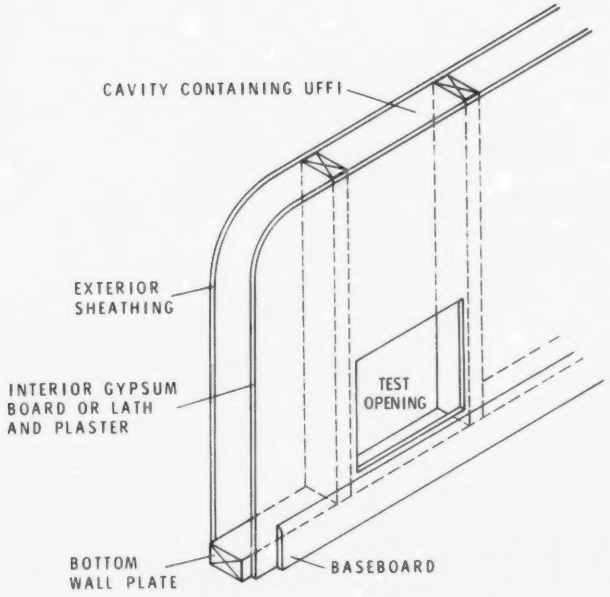
CAVITY CONTAINING UFFI
EXTERIOR SHEATHING
INTERIOR GYPSUM BOARD OR LATH AND PLASTER
TEST OPENING
BOTTOM WALL PLATE
BASEBOARD

FIGURE B1
TEST OPENING

APPENDIX C

FUNGI ISOLATED FROM UFFI

Problems involving fungi associated with UFFI have been rare but some cases have occurred. Homeowners experiencing medical problems should not assume, therefore, that fungi are present but should consult with the appropriate experts as discussed in the text. The following information, prepared by Health and Welfare Canada for NRC, is provided in this document as an assistance to the consultants or experts because of the difficulty in obtaining and scarcity of information on the species identified.

Alternaria spp. - a genus of dematiacious Fungie Imperfecti of the order Moniliales. It causes several diseases of plants and has been reported in diseases of the lungs and in skin infection in man, and is also a common allergen in human bronchial asthma.

Aspergillus spp. - causes a diseased condition marked by inflammatory granulomatous lesions in the skin, ear, orbit, nasal sinuses, lungs, and sometimes in the bones and meninges; called also aspergillomycosis.

Aspergillus versicolar - a species of common soil saprophytes often isolated from dried salted beef.

Cladosporium resinae - found in kerosene-type fuel from jet aircraft.

Paecilomyces varioti - common fungus in the air, soil, compost, wood and food-stuffs. Although generally considered as a saprophyte, it can apparently become pathogenic in man and animals, causing paecilomycosis.

Penicillium spp. - may cause a pulmonary infection called penicilliosis.

Paecilomyces farinosus - causes a mycotic disease in man and animals called paecilomycosis.

Trichoderma spp. - a genus of soil fungi, some species of which cause alimentary toxic aleukia (absence of leukocytes - white cells - from the blood).

APPENDIX D

COMMON TYPES OF HOUSE CONSTRUCTION

1. Platform Frame (Figure D1)

Description:

Platform frame construction is the most common type of wood frame house construction. A house is constructed by erecting the walls for each storey from the platform formed by the floor joists and subflooring. The subfloor is placed on the platform before erecting the walls. The walls consist of studs, usually at 400 mm on centre, with top and bottom plates, the cavity is enclosed by lath and plaster or gypsum board on the interior, and sheathing on the exterior. The UFFI was usually installed in the cavity between the studs although there have been cases of UFFI installed between brick veneer and the exterior sheathing.

Comments:

- where board subflooring is present, it will be necessary in some cases to seal between the boards on both sides of the wall plate. This will require special techniques and equipment, now being studied. The effectiveness of a continuous gasket or bead of sealant applied along the base of the wall behind the baseboard, will be reduced by air infiltration between the boards.
- where it is necessary to remove UFFI placed between brick veneer and the sheathing, it will have to be done from the exterior.

2. Balloon Frame (Figure D2)

Description: -

Many older houses were constructed using this approach. On the first floor, the joists sit on the bottom plate of the wall and are nailed to the studs. The joists extend to the outside of the wall. The stud spaces were sometimes fire stopped at the floor levels. Although required by building codes this was often omitted. In some cases nailer strips were installed to carry the subflooring between joists. The joist space is not closed at the wall line and is open to the wall cavity. The wall studs are continuous through the second floor line and the second floor joists are set on a ledger let into the studs.

Comments:

- this type of construction is very difficult to seal adequately due to the connections between wall cavity and joist spaces. More emphasis on pressurization is necessary.

- floor spaces may have been insulated due to the connection between the wall cavity and joist spaces. These should be checked.

3. Plank Frame (Figure D3)

Description:

Plank frame construction consists of vertical posts approximately 250-350 mm in width, spaced at 2.5 to 3 m intervals supporting lintels approximately 250 mm in depth. The space between the floors was then filled in with planks from post to post. The space between the joists at the exterior wall was commonly filled with solid blocking. Furring strips were placed on the interior surface before applying lath and plaster or gypsum board. When the exterior cladding was brick veneer, UFFI was installed between it and the plank wall. In other cases it was installed between the inside surface and the plank wall in the cavity created by the furring.

Comments:

- where UFFI is located between the brick veneer and the plank wall and removal is necessary, it will have to be done from the exterior.

- the location of the UFFI will affect the success of sealing the exterior wall as a remedial measure.

- if the solid blocking between the joists was omitted, or knocked down during UFFI application, UFFI may have entered the floor space.

4. Masonry

Description:

Masonry construction is characterized by exterior walls of multiple wythes of brick or concrete block or a combination of both. The wall may or may not contain an airspace. Furring strips of about 20 mm are fastened to the masonry and the interior lath and plaster applied to them. The cavities that were insulated with UFFI included the 20 mm space between the interior finish and masonry and the cavities within the masonry wall.

Comments:

- UFFI installed in cavities enclosed by masonry such as the cores of concrete block walls or between wythes of masonry is, in most cases, very difficult if not impractical to remove.

- the joist space may be connected to the wall cavity created by the furring strips and may require additional effort to seal.

- pressurization of the living space will minimize infiltration in most of the areas which cannot be sealed effectively.

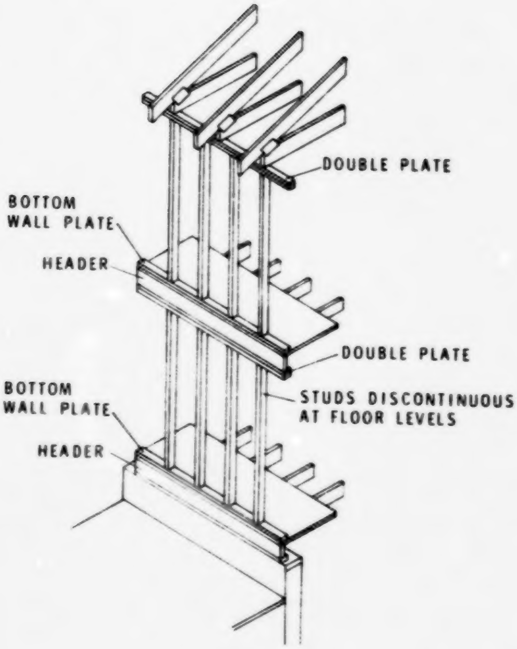
DOUBLE PLATE
BOTTOM WALL PLATE
HEADER
DOUBLE PLATE
BOTTOM WALL PLATE
STUDS DISCONTINUOUS AT FLOOR LEVELS
HEADER

FIGURE D1

PLATFORM FRAME CONSTRUCTION

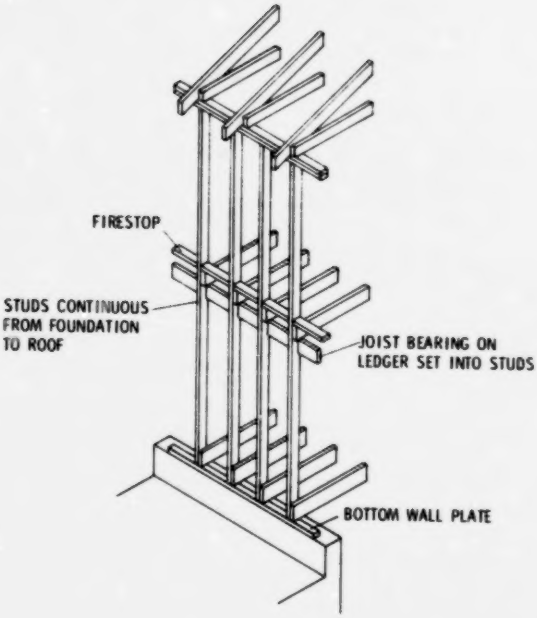
FIRESTOP
STUDS CONTINUOUS FROM FOUNDATION TO ROOF
JOIST BEARING ON LEDGER SET INTO STUDS
BOTTOM WALL PLATE

FIGURE D2

BALLOON-FRAME CONSTRUCTION

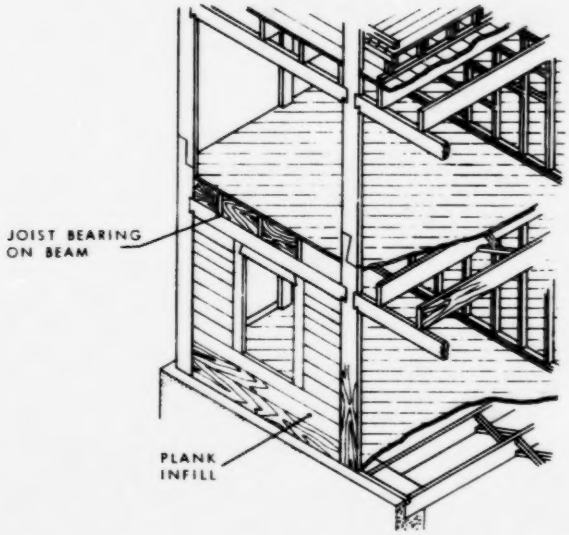
JOIST BEARING ON BEAM
PLANK INFILL

FIGURE D3
PLANK FRAME CONSTRUCTION

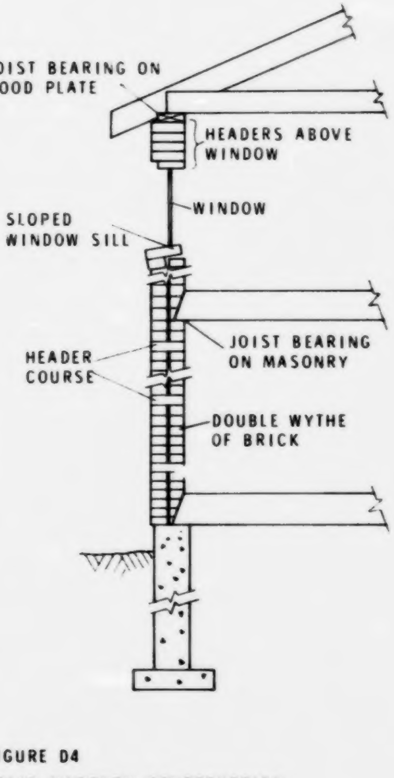
JOIST BEARING ON WOOD PLATE
HEADERS ABOVE WINDOW
WINDOW
SLOPED WINDOW SILL
JOIST BEARING ON MASONRY
HEADER COURSE
DOUBLE WYTHE OF BRICK

FIGURE D4
SOLID MASONRY CONSTRUCTION

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POOR

QUALITY

ORIGINAL